Implant- versus collar-transmitter use on black bears

Gary M. Koehler, P. Briggs Hall, Mary H. Norton, and D. John Pierce

Abstract Bears are difficult to radiomark for long-term studies because of juvenile growth rates, dramatic seasonal weight changes, and similar head and neck girths for adults. Because collars may be discarded if mounted too loosely or cause neck ulcerations if mounted too tightly, we compared use of collar and implant radiotransmitters for black bears (Ursus americanus) at 3 locations in Washington during 1994–1999. We marked 22 females and 38 males with collar transmitters and 30 females and 40 males with implant transmitters. Marking bears with collars or implants and collecting morphological data and specimens required 20–55 minutes. Amount of Telazol™ used to anesthetize bears marked with collars and to conduct implant surgery and amount of drug used between fall and spring captures differed significantly. Amount of drug did not differ between genders or for bears captured by helicopter or snares. Bears lost collars with cotton breakaway spacers after approximately 21 (±3.4, SE) months in the study area where mean annual precipitation was 52 cm, and 10 (±2.5) months where mean annual precipitation was 200 cm. For bears marked with collars, detection rates (number of radiotelemetry relocations/aerial monitoring session) were similar for males and females and among study areas. In contrast, we detected implant-marked males at lesser rates than females and detected bears at different rates among study areas. Decreased signal strength for implant transmitters resulted in fewer locations and greater search effort for males because they used larger spatial areas and were more difficult to relocate than females. Differences in numbers of relocations obtained for male and female black bears marked with implant transmitters may affect precision of spatial and habitat use estimates and gender comparisons of resource use and mortality rates. For these reasons, implant transmitters may be adequate to monitor animals with small home ranges but may not be appropriate to monitor wide-ranging animals.

Key words black bears, drug dosage, implant transmitters, radiocollars, radiotelemetry, surgery, Ursus americanus

When using radiotelemetry for demographic, behavioral, and ecological studies of long-lived species, transmitters should be retained on the animal as long as possible while remaining safe and humane to the animal, to minimize the expense and effort required to capture and mark animals (White and Garrott 1990). Black bears *(Ursus americanus)* present a challenge for marking with transmitters collars because of growth from juvenile to adult, dramatic seasonal weight gain and loss, and similar girth of neck and head (Jessup and Koch 1984, Garshelis and McLaughlin 1998). Transmitter collars may cause neck ulceration if mounted too tightly or may fall off if mounted too loosely. Large males are particularly difficult to fit properly with collars. Expandable or breakaway features can accommodate some of these concerns (Hellgren et al. 1988, Garshelis and McLaughlin 1998), but can

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also reduce amount of time an individual retains its collar. Additionally, transmitter collars may not be acceptable to the public in wildlife viewing areas and may not provide reliable hunter harvest data if collars are destroyed accidentally or intentionally to conceal a kill.

To obtain more reliable long-term radiotelemetry data for several age and size classes of bears and to obtain more reliable mortality data from hunter harvests, we tested use of abdominal implant transmitters. We compared amount of drug required to mark bears and compared detection rates between bears with implant transmitters and those marked with collar transmitters in Washington during 1994–1999.

Study area

We conducted our study at 3 sites in Washington: Olympic, Snoqualmie, and Okanogan. The Olympic study area (47°N 123°W), on the Olympic Peninsula, had elevations of 60–2,370 m mean sea level and mean annual precipitation of 380 cm. This area was managed as private commercial tree plantations, for multiple use by the United States Forest Service, and as wilderness by the United States Park Service. Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and silver fir (*Abies amabilis*) were the dominant tree species. Elevations for the Snoqualmie study area, on the west slope of the Cascade Range (47°N 121°W), were 134–1,826 m mean sea level and mean annual precipitation of 200 cm at 134 m mean sea level. The Snoqualmie was managed as a private commercial tree plantation and for multiple use by the United States Forest Service with Douglas-fir, western hemlock, and silver fir being dominant tree species. The Okanogan study area, on the east slope of the Cascades (48°N, 120°W), had elevations of 535–2,763 m mean sea level and mean annual precipitation of 52 cm at 535 m mean sea level. Douglas-fir, Ponderosa pine (*Pinus ponderosa*), Engelmann spruce (*Picea engelmannii*), and alpine fir (*A. lasiocarpa*) were dominant tree species. This area was managed predominantly as wilderness and for multiple use by the United States Forest Service, with interspersed livestock ranches and private residences.

Methods

We captured bears in Aldrich snares or darted them from a helicopter. They were anesthetized with tiletamine HCl and zolazepam HCl (Telazol™, Fort Dodge Laboratories, Fort Dodge, Ia., USA). We estimated weight of captured bears and administered doses of 4.4–5.5 mg Telazol/kg of body weight (White et al. 1996) by 2.5-cc syringe mounted on a jab-stick or 3.0-cc dart fired from a CO_2-powered dart gun. We determined gender, weighed and took morphological measurements, ear-tagged, lip-tattooed, extracted premolar, and collected tissue and blood samples. Research activities were conducted in accordance with Washington State University Animal Subjects Approval LARC 2745.

We captured bears on the Okanogan study area in 1994–97 and marked them only with transmitter collars. On the Olympic study area, we captured and marked bears with implants in 1997 and 1998. On the Snoqualmie, we marked bears with collars in 1994, collars or implants in 1995, and implants only in 1996. We captured most bears in April–July. Transmitter collars were manufactured by Advanced Telemetry Systems (Isanti, Minn., USA) and Lotek Engineering (Newmarket, Ontario, Canada). Transmitter collars weighed 400–525 g and were fitted with cotton spacers designed to break away (Hellgren et al. 1988). Implant transmitters weighed 150–225 g and measured 4 × 12.5 to 3 × 16 cm (Advanced Telemetry Systems, Figure 1). Frequencies ranged from 149.00 to 152.00 MHz.

Veterinarians P. B. Hall, M. H. Norton, and volunteer veterinarians conducted implant procedures in the field at the capture site. Implants were immersed for 1 hr in cold-sterilization chlorhexidine solution and rinsed with sterile saline prior to

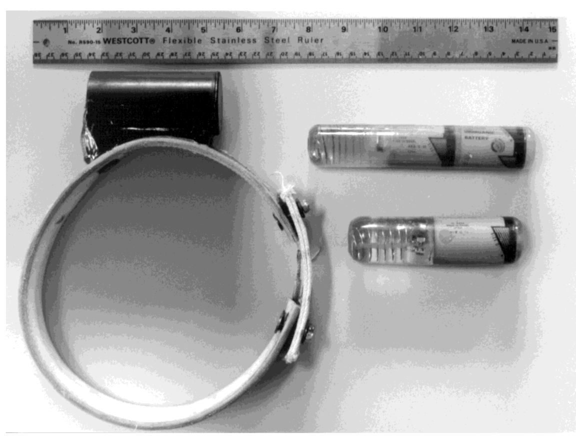

Figure 1. Comparisons of 2 styles of implant and collar transmitters (Advanced Telemetry Systems, Isanti, Minn., USA) used on black bears in Washington. The upper implant transmitter weighs 165 grams and the lower transmitter weighs 175 grams. Note the cotton spacer on the collar, which is placed on the inside of the collar when mounted on a bear.

insertion. We prepared each bear for surgery by placing an intravenous catheter in the cephalic vein with a lactated Ringer's solution intravenous drip. We used the catheter to administer additional anesthetic if needed. We gave a long-acting antibiotic, benzathine penicillin, intramuscularly.

With the bear in dorsal recumbency on an insulated pad, we shaved the ventral midline from approximately 7 cm anterior to the navel to the prepuce in males or distal in females for approximately 20 cm and a width of approximately 10 cm. We surgically scrubbed the shaved area with povidone–iodine solution and alcohol and draped the prepared site with a sterile disposable surgical drape. We infiltrated the incision line with 2% lidocaine hydrochloride and made a 4- to 6-cm incision into the peritoneal cavity along the avascular midline where bleeding was minimal. We guided the implant transmitter through the incision and allowed it to drop into the abdominal cavity. We closed the abdominal cavity using a simple interrupted suture pattern with #2-0 to #1 synthetic absorbable suture material while apposing subcutaneous tissue. We sutured skin with #2-0 to #0 suture material with a continuous subcuticular suture pattern and sealed the incision with cyanoacrylate.

Weather permitting, we monitored bears from fixed-wing aircraft twice weekly from den emergence (approximately 1 April) to den entrance (approximately 1 November). We monitored telemetry locations from a Cessna 182 or 185 on which a 2-element, 4-dBd gain "H antenna" (model RA-2A, Telonics Inc., Mesa, Ariz., USA) was mounted on each wing strut at 45° angles. We used a programmable scanner receiver (Telonics Inc., Mesa, Ariz., USA) with scan rates set at approximately 1.2 seconds. We initially searched the area where a bear was last located, and if it was not relocated, we conducted concentric circular searches from this location. In addition, before ending aerial telemetry sessions we searched for undetected bears by flying a grid pattern of the study area.

We calculated annual rate of aerial telemetry detection for each bear by dividing number of aerial telemetry relocations by number of aerial searches conducted for each bear. Detection rates assumed that each individual was searched for during each flight, which was violated infrequently due to localized weather patterns that prevented a thorough search.

We did not compare radio signal transmission distance for implant and collar transmitters because the size and position of a bear relative to the receiving antenna, vegetation, and topographic features influenced signal transmission and these effects could not be determined in each case. Instead, we evaluated effectiveness of signal transmission by comparing percentage of successful relocation attempts obtained for bears marked with implants or collars. We normalized detection rates for individual bears using arcsine transformation and used multi-factor ANOVA (Zar 1984) to compare detection rates and test for interactions of gender, transmitter type, and study area. We also used multi-factor ANOVA to compare and test for interactions of drug dosage for gender, capture method, season, and transmitter type.

Results

We marked 22 females and 38 males with collar transmitters and 30 females and 40 males with implant transmitters. We recaptured some bears with collars and remarked them with implant transmitters. We captured 9 of the implant-marked bears by helicopter in September–October and the remainder in April–July. Weights of bears marked with collars (77.0±30.5 kg; $\bar{x}$±SE) were similar ($F_{1,121}=0.10$, $P=0.75$) to those marked with implants (78.9±36.3 kg).

We tested for amount of Telazol used among gender, capture method, season, and whether bears were marked with collars or implants and did not detect ($F_{1,117}=1.38$, $P=0.24$) any interactions among these effects, but drug dosage did differ among season ($F_{1,117}=9.54$, $P=0.003$) and for bears marked with collars or implants ($F_{1,117}=6.44$, $P=0.01$). We used 9.3±0.9 mg/kg of Telazol for 4 females and 5 males captured in fall and 6.3±0.3 mg/kg for bears captured in summer. We used 7.0 ±0.4 mg/kg for anesthetizing 58 collared bears and 6.0±0.3 mg/kg during surgical implant procedures for 65 bears. Amount of drug used to anesthetize 45 females (6.8±0.4 mg/kg body weight) and 78 males (6.3±0.4 mg/kg) was similar ($F_{1,117}=0.39$, $P=0.53$), as was amount of drug used to anesthetize 30 bears darted from a helicopter (7.5±0.4 mg/kg) and 93 bears darted in snares (6.2±0.3 mg/kg, $F_{1,117}=0.39$, $P=0.53$).

Once bears were anesthetized, we required 20–30 minutes to mount a collar, mark, record morphological measurements, and collect specimens. Surgical procedures required 20–55 minutes, during which we marked, recorded morphological measurements, and collected specimens. All bears remained immobile (unable to hold head up) for >60 minutes.

Fifteen bears on the Okanogan study area dropped collars an average of 21 (±3.4) months after being marked, whereas 13 bears on the Snoqualmie dropped collars 10 (±2.5) months after being marked. None of the 3 recaptured and 19 reported hunter-harvested bears marked with implants showed signs of complications from surgery, whereas 2 of 16 recaptured and 1 of 18 reported hunter-harvested bears marked with collars had necrotic ulcerated necks.

Although we did not observe ($F_{2,114}$=0.88, P= 0.42) an interaction among study area, gender, and transmitter type on detection rates, we did observe differences in rates for area, gender, and transmitter type ($F_{6,114}$=15.9, P<0.001). For bears marked with collars, we observed no differences ($F_{2,55}$= 2.68, P=0.08) in detection rates between 19 females (0.76±0.03 detections/flight) and 39 males (0.70±0.03 detections) or for collared bears on the Okanogan and Snoqualmie study areas.

In contrast, we did observe differences ($F_{2,60}$= 26.96, P<0.001) in detection rates between gender and study area for implant-marked bears. We observed greater detection rates for females (0.62± 0.03, n=27) than males (0.39±0.03, n=36, $F_{1,60}$= 47.44, P<0.001), and we detected bears on the Olympic study areas at greater rates (0.55±0.04, n= 25) than those on the Snoqualmie (0.45±03, n=38, $F_{1,60}$=13.93, P<0.001).

For the Snoqualmie study area where bears were collared or implanted, collared females had the highest detection rate and implanted males the lowest ($F_{2,61}$=30.10, P<0.001). Here, we detected collared females more frequently (0.76±0.03, n=9) than implanted females (0.59±0.04, n=19) and collared males (0.64±0.04, n=17) more frequently than implanted males (0.32±0.03, n=19). We did not compare duration of transmission service for collars and implants because we were not certain whether censured implants resulted from lack of detection or diminished batteries, but both transmitted for >3 years.

Discussion

In this study, time required to process captured animals, 22–55 minutes, was similar for bears marked with implants or collars and comparable to the 30–45 minutes reported by Philo et al. (1981) for conducting abdominal implant surgery on grizzly bears (*Ursus arctos*). Dosages of Telazol described by White et al. (1996) were adequate for anesthetization, with bears remaining immobile >1 hour and providing ample time to mark bears, collect specimens, and record data. Mean dosage during this study was 6.4 mg Telazol/kg body weight, with a range of 2.3–16.5 mg/kg, which reflects the difficulties in accurately estimating weights of captured animals, differences in drug tolerances for individual bears, and season when bears were captured. We did not document any physical complications from the abdominal surgical procedures, but did document necrotic ulcerated necks for 3 bears marked with collars. Hellgren et al. (1988) observed that collars with breakaway cotton spacers did minimize neck lacerations, but, as we observed, they found that cotton spacers rotted and broke away more quickly in humid areas. Davis et al. (1984) did not document surgical complications for intraperitoneal implanted transmitters in beavers (*Castor canadensis)*. In contrast, Jessup and Koch (1984) found that implanting transmitters in the rhomboideus muscles of black bears was not successful because transmitters were sloughed due to surgical failure or removed by the bear itself or by another bear. Although the implant procedure required a simple operation that personnel with limited surgical training could perform, presence of a veterinarian is advised as surgical or anaesthetizing complications may occur.

Although we relocated males and females marked with collars with similar probabilities, males marked with implants were most difficult to locate. We suspect the reduced signal strength for implants (Philo et al. 1981) and attenuation of the signal by the males' greater mass reduced opportunities for detection in the large home ranges males use (Pelton 1982). Thus, a greater telemetry search effort was required, which resulted in lower detection probabilities for males marked with implants. Jessup and Koch (1984) documented reduced signal transmission range for abdominally implanted transmitters on bears, as did Green et al. (1985) for monitoring captive coyote (*Canis latrans*) and kit foxes (*Vulpes macrotis*). Philo et al. (1981) observed that abdominal implants in grizzly bears could be detected by aerial telemetry at 0.4–0.8 km. In our study, reduced signal strength for implants, signal interactions with terrain, and skill of aerial observers may explain the differences in detection rates among study areas for implant-marked males and females, whereas detection rates were similar between genders and study areas for collared bears.

While using a programmable receiver–scanner, we observed that bears frequently were passed undetected as the scanner unit cycled through the searched frequencies during telemetry flights. Several passes were required over areas where bears were believed to occur, and this was a particular problem for >12 bears occupying a small (<90-km^2) area. However, we did not observe this problem with collar transmitters because their stronger signal could be detected at greater distances. Longer scan rates may help resolve this problem but may compromise searches for other bears.

Additionally, bears in winter dens were more difficult to relocate if marked with implants because the reduced signal was further attenuated by the bear's position in the den and terrain features nearby (Philo et al. 1981). We often detected signals from dens as a narrow cone emanating from the entrance, and we easily missed these signals during telemetry flights.

Fewer relocations for males would likely result in less precision and possibly bias home range estimates and gender comparisons of habitat use patterns and mortality rates. Fewer relocations obtained for males marked with implants would result in underestimating spatial use areas calculated with the minimum convex-polygon estimator (White and Garrott 1990) and overestimating spatial use areas calculated with the kernel estimator (Seaman et al. 1999). This bias may be minimized by greater search effort, which would require additional aerial tracking time and expense.

Because of the greater difficulty in relocating males, it was not possible to determine whether censure resulted from our inability to detect the signals, a nonfunctioning transmitter, or unreported hunter harvest. As a result, implant transmitters did not improve hunter-harvest data collection.

Although costs for implant and collar transmitters are similar, the additional cost for veterinarian services made implant procedures more expensive. We did not consider transporting immobilized bears to veterinarian clinics for surgery because of animal welfare concerns involving the long and difficult transport time from remote capture locations. In addition, once bears were captured in snares, we believed it was important to immobilize and process them quickly to minimize physical injuries and physiological stress from restraint. For these reasons, we believed it necessary for a veterinarian to accompany capture crews. Veterinarian volunteers did help minimize costs, and they considered the opportunity to work with bears as reward.

We believe implant transmitters may be appropriate where public viewing of wildlife is a consideration, where transmitter collars may be considered intrusive or unnatural, for animals that are difficult to mark with collars, or where collar injuries may be an important consideration. Use of implant transmitters may provide reliable data for animals that have small home range sizes but may not be appropriate for wider-ranging animals.

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