Transmitter Height Influences Error of Ground-based Radio-telemetry

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Source: Wildlife Biology, 13(1) : 98-101

Published By: Nordic Board for Wildlife Research

URL: https://doi.org/10.2981/0909-6396(2007)13[98:THIEOG]2.0.CO;2

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Townsend, D.E., II, Ditchkoff, S.S. & Fuhlendorf, S.D. 2007: Transmitter height influences error of ground-based radio-telemetry. - Wildl. Biol. 13: 98-101.

Although accuracy of wildlife radio-tracking systems have been measured intensively, little attention has been given to error associated with varying transmitter heights that would occur because of species size or life history (e.g. arboreal species). Our objective was to simulate the approximate transmitter height of three extensively studied game species to determine their influence on bearing accuracy. Error rates were 4-fold greater at simulated transmission heights of northern bobwhites *Colinus virginianus* (15 cm; $\bar{x} = 24.37$) and wild turkey *Meleagris gallopavo* (46 cm; $\bar{x} = 24.46$) than at transmission heights of white-tailed deer *Odocoileus virginianus* (92 cm; $\bar{x} = 6.43$). Results suggest that error differences associated with transmitter height can have a dramatic influence on measures of habitat selection. We discuss the implications of variation in transmitter height on study design and its potential influence on estimated rates of error.

Key words: animal location, bobwhite quail, Colinus virginianus, error, Meleagris gallopavo, Odocoileus virginianus, telemetry, white-tailed deer, wild turkey

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Received 10 September 2004, accepted 28 December 2005

Associate Editor: John W. Connelly

Animal locations obtained from telemetry data are typically estimated by assigning confidence limits on bearings associated with either a 90% error polygon (Springer 1979) or a 95% confidence ellipse (White 1985). Accuracy of a telemetry location is a function of the location of the telemetry receiving station, the location of the animal relative to the receiving stations, and precision of the telemetry bearings (White

& Garrott 1986). Because triangulation is commonly used for obtaining location estimates, deviation between the true bearing and location bearing can have a profound influence on estimating an animal's location and determining its position within a specific habitat type (White & Garrott 1986). Although accuracy of wildlife radio-tracking systems has been evaluated previously (Springer 1979, Hupp & Ratti 1983, Lee et al. 1985, White & Garrott 1990), little attention has been given to error associated with the height of the radio-transmitter relative to specific species. Our objective was to measure directional telemetry error at three transmitter heights (simulating three extensively studied game species: white-tailed deer *Odocoileus virginianus*, wild turkey *Meleagris gallopavo*, and bobwhite quail *Colinus virginianus*) to determine their influence on bearing accuracy. We hypothesized that telemetry error rates would be negatively associated with transmitter height.

Study area and methods

Telemetry data were collected on the Oklahoma State University Range Research Station located approximately 21 km southwest of Stillwater, Oklahoma. The area consists of 1,400 ha of tallgrass prairie and cross-timbers habitats. The prairie vegetation is typical of tallgrass prairie in a high seral stage, but some local communities are representative of cross-timbers vegetation of post oak *Quercus stellata*, blackjack oak *Q. marilandica*, and eastern red cedar *Juniperus virginiana*. Our trials were conducted during the winter of 2000 and at a relatively uniform location to reduce error associated with physical barriers such as macrotopography (i.e. riparian vs upland), and different vegetation zones (i.e. shrubs or tall trees with limited leaf surface area) that may be capable of disrupting signal strength. As a result, our study site was located exclusively within tallgrass prairie with slopes of $< 3\%$ that provided conditions free from physical obstruction. Dominant grasses on this site included little bluestem *Schizachyrium scoparium*, big bluestem *Andropogon gerardii* and indiangrass *Sorghastrum nutans*.

We placed 12 permanent transmitter stations randomly within the study site, and established four permanent radio-telemetry receiving stations every 100 m along a 0.4-km section of road that traversed the site. At each transmitter station, we placed a 1.5-m piece of PVC pipe (so as not to influence transmitter signal) into the ground and established transmitter positions at 15, 46, and 92 cm elevations to simulate approximate transmitter position of northern bobwhites, wild turkey and white-tailed deer, respectively. At each transmitter station a 6-g radio-transmitter (American Wildlife Enterprises, Monticello, Florida; Model AWE-01) was randomly positioned at one of three transmission heights. Transmitter bearing locations were estimated by a single operator using a radio receiver (Wildlife Materials Inc., Carbondale, Illinois), a 3-element yagi antennae, and a hand-held compass. Telemetry error was determined by conducting a series of three trials, where one trial consisted of 48 bearings (12 radio-transmitters $\times$ 4 receiver stations). In each subsequent trial, radio-transmitters were repositioned randomly to a different transmission height so that bearings from each transmission height at all transmitter stations were recorded. Universal Transverse Mercator (UTM) coordinates and elevations of receiver and radio-transmitter stations were determined using a hand held GPS receiver (Trimble Navigation Limited, 2001). Location of radio-transmitters remained unknown to the person who was conducting the test. By selecting a site located exclusively within tallgrass prairie habitat, we ensured that the telemetry operator would have difficulty associating landmarks with telemetry bearings. Our telemetry operator had four years of previous telemetry experience to ensure that error was representative of an experienced researcher.

Error for test transmitters at known locations was determined by calculating the absolute value of the difference between true and test bearings. We tested for differences in error associated with transmitter heights using analysis of variance (PROC ANOVA; SAS Institute, Inc. 2000). To assess influence of distance between telemetry stations and test transmitters as well as absolute difference in elevation between telemetry stations and test transmitters on bearing error, we used stepwise regression analysis (PROC REG; SAS Institute, Inc. 2000) with bearing error as the dependent variable and distance between transmitter and receiver and elevation as independent variables. Variables selected for inclusion in the model were deemed to be significant when $P \leq 0.15$ (Hosmer & Lemeshow 1989, Townsend et al. 1999, Ditchkoff et al. 2001).

Results and discussion

During our study we recorded 144 test bearings. Mean bearing error across all transmitter heights was 18.4°

Table 1. Mean telemetry bearing error (in °) for transmitter heights of 15, 46 and 92 cm above the surface of the ground, simulating the approximate transmitter positions of bobwhites, wild turkey and white-tailed deer, respectively. For transmitter height above ground, the values sharing the same letter are not different (P > 0.05; Duncan's multiple range test for bearing error).

Animal simulated	Transmitter height above ground (cm)	N	$\bar{x}$	SE	SD
Bobwhite	15[a]	48	24.37	2.15	14.86
Wild turkey	46[a]	48	24.46	1.94	13.43
White-tailed deer	92[b]	48	6.43	0.85	5.85

(SD = 14.7°). Mean distance between test transmitters and telemetry stations was 264 m and distances ranged within 105-514 m. Distance between telemetry stations and test transmitters and absolute difference in elevation between telemetry stations and test transmitters had no influence ($P \geq 0.05$) on bearing error. However, error rates were approximately four times greater at transmitter heights of 15 and 46 cm than at heights of 92 cm (Table 1), indicating that micro-topography may influence bearing error when signals are transmitted from heights of ≤ 46 cm. In fact, 40 and 44% of bearings taken from test transmitter heights of 15 and 46 cm, respectively, were associated with error rates of ≥ 26° (Fig. 1). In contrast, 50% of all bearings taken from test transmitter heights of 92 cm were associated with error rates of ≤ 5°.

Although radio-transmitter signal strength will vary by species depending on the size of the transmitter (e.g. signal strength), our data suggest that differences in error associated with transmitter height can have a dramatic influence on the accuracy of telemetry locations. Biologists, when locating transmitters by triangulation, should be familiar with the precision of their location estimate to ensure data accuracy (Nams & Boutin 1991). Depressions in terrain and stands of dense vegetation affect signal strength and bias location estimates (Lee et al. 1985, White & Garrott 1990). Our data suggest that slight variations in micro-topography (i.e. within 1 m^2) may have a significant influence on bearing error. Thus, under similar radio-telemetry conditions (i.e. habitat types and distances from transmitter to receiver), location estimates of smaller animals that have transmission heights relatively close to the ground (≤ 46 cm) may be less accurate than location estimates of animals that have transmission heights of > 46 cm.

Another important variable that may influence error rates of telemetry studies is life history of the study animal. In many species, transmitter height will vary little during the life of the animal because they spend their entire lives on the ground. However, arboreal species, which are normally small in size, may spend considerable time at ground level where error rates are high, but also considerable time in trees where error rates would be negligible. In this case, error rates could vary substantially within a study depending upon the habits of the species. Along these lines, it is critical that life history and size of the animal

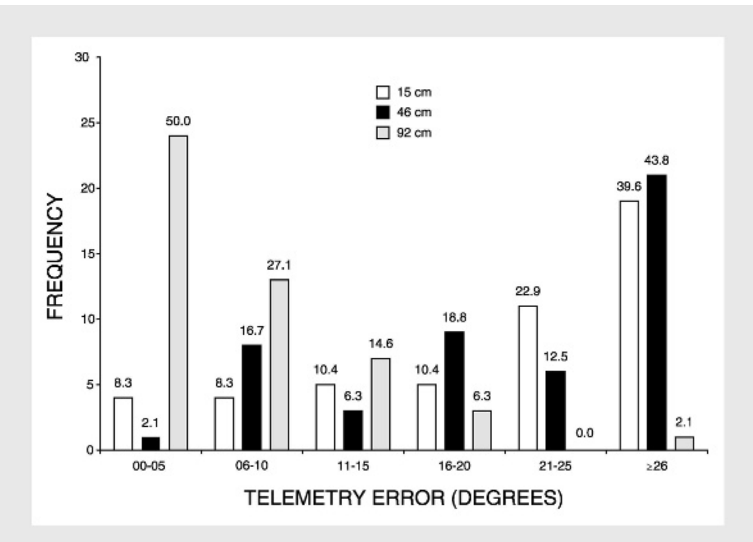

Figure 1. Frequency histogram of bearing errors associated with transmitter positions of 15, 46, and 92 cm above the surface of the ground, respectively, determined from blind accuracy tests. Numbers above bars indicate the percentage of all bearings within a particular height class.

be taken into account when designing protocol to evaluate telemetry error rates. For instance, if the species of interest spends time both on the ground and elevated in trees, then those variable error rates (associated with daily activities) at ground level and canopy level should be considered. When transmitters are randomly located for determination of telemetry error, they must be established at a height or a series of heights appropriate for each study animal, else estimated error rates could substantially under- or overestimate telemetry error.

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