Effects of Environmental Conditions on Performance of Vaginal Implant Transmitters

CHAD H. NEWBOLT,[1] *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA*
STEPHEN S. DITCHKOFF, *School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL 36849, USA*

ABSTRACT Vaginal implant transmitters (VITs) are increasingly used to facilitate capture of neonatal ungulates. Environmental conditions potentially have a significant influence on performance of VITs; however, effects on VIT performance largely are unknown. We exposed VITs to conditions reflective of those present during white-tailed deer fawning season in Alabama and examined effects of ambient air temperature and vegetative structure on their performance. Performance of VITs was inversely related to ambient air temperature, and VIT performance increased along with increasing amounts of shade provided by vegetation. Current devices likely will perform relatively well if expelled in areas where ambient air temperatures are below the user-defined pulse switch point and habitat conditions provide shade. Performance of VITs will be severely compromised if expulsion occurs in areas where ambient air temperatures are above the user-defined pulse switch point and devices are exposed to direct sun. Individuals interested in utilizing VITs should consider local climate and vegetative characteristics prior to initiating projects to evaluate if devices will meet performance requirements. (JOURNAL OF WILDLIFE MANAGEMENT 73(2):303–305; 2009)

DOI: 10.2193/2007-498

KEY WORDS calf, fawn, neonate, ungulate, vaginal implant transmitter.

Use of vaginal implant transmitters (VITs) has become a popular method of locating neonatal ungulates (Delgiudice et al. 2006, Johnstone-Yellin et al. 2006, Bishop et al. 2007, Saalfeld and Ditchkoff 2007). Early VITs had functional and ethical issues that restricted their utility; however, many of these issues have been resolved in current models (Garrot and Bartmann 1984, Johnson et al. 2006). Vaginal implant transmitters consist of a small radio transmitter implanted in the vaginal canal of adult females following the breeding season and are held against the cervix of the target animal by flexible silicone wings until expelled during parturition (Bishop et al. 2007). Vaginal implant transmitters are temperature sensitive and emit a specific number of pulses/minute depending upon detected temperature. The temperature at which pulse frequency changes is defined by the user; however, VITs often are programmed to emit 40 pulses/minute when temperatures are $\geq$34° C and 80 pulses/minute at $\leq$30° C (Seward et al. 2005, Johnstone-Yellin et al. 2006, Saalfeld and Ditchkoff 2007). Sensitivity of VITs to temperature change varies between units, resulting in a 4° C range of error in current models (T. Garin, Advanced Telemetry Systems, personal communication). Ideally, VITs are exposed to lower temperatures following expulsion at parturition, leading to a change in pulse frequency. The change in pulse frequency alerts researchers that the target animal has given birth, and the expelled transmitter leads to the birth site and facilitates capture of newborns.

Vaginal implant transmitters may provide many benefits to individuals involved in studies requiring capture of newborn ungulates, including increased capture rates, reduced sample bias, and unique research opportunities (Bishop et al. 2007). However, researchers have identified factors that currently restrict applicability of these devices, such as high failure rates and expense (Bishop et al. 2007). Utility of VITs also may be reduced in areas where expelled devices are subjected to high air temperatures or intense solar irradiation that prevents them from emitting a pulse indicative of expulsion. For example, daytime temperatures in the southeastern United States often exceed 34° C during peak fawning season, which may compromise effectiveness of VITs in this environment. However, relationships between environmental conditions and performance of VITs have not been evaluated and remain unclear.

Financial expenses and labor associated with VITs necessitate an understanding of relationships between environmental conditions and VIT performance. This knowledge will allow researchers to better evaluate potential utility of VITs in a given area prior to initiating projects and will allow researchers to develop efficient monitoring programs that direct efforts to time periods when the devices have a high probability of proper functionality. Our objective was to examine how environmental conditions (e.g., ambient air temp and vegetative structure) influence performance of VITs.

STUDY AREA

We conducted this study near Auburn University, Auburn, Alabama, USA. Vegetation in the immediate area comprises oak–hickory and planted pine forests with interspersed fields commonly used for pasture. Daytime temperatures in this area during white-tailed deer (*Odocoileus virginianus*) fawning season typically are very warm, often exceeding 32° C. Mean daily high and low temps in Auburn during the study were 30° C and 21° C, respectively.

METHODS

We evaluated performance of 16 VITs (Models M3950 and M3930; Advanced Telemetry Systems, Isanti, MN) for 16 days during July 2007. We had VITs programmed to emit 40 pulses/minute when temperatures were $\geq$34° C and 80

[1] *E-mail: newboch@auburn.edu*

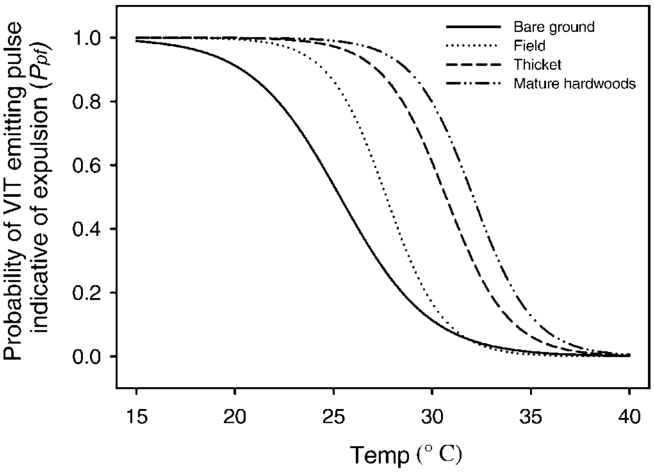

Figure 1. Relationships between ambient air temp (° C) and probability (P_{pf}) of vaginal implant transmitters emitting pulse frequency indicative of expulsion, in Alabama, USA, July 2007. Values were calculated from probability equations derived from univariate logistic-regression models ($P \leq 0.001$).

Table 1. Probability equations used to determine relationships of ambient air temp (T) to probability (P_{pf}) of vaginal implant transmitters emitting pulse frequency indicative of expulsion, in Alabama, USA, July 2007. Equations derived from univariate logistic-regression models.

Habitat	Equation
Bare	$P_{pf} = \frac{e^{\left(11.160-0.441(T)\right)}}{1+e^{\left(11.160-0.441(T)\right)}}$
Field	$P_{pf} = \frac{e^{\left(19.156-0.692(T)\right)}}{1+e^{\left(19.156-0.692(T)\right)}}$
Thicket	$P_{pf} = \frac{e^{\left(19.289-0.628(T)\right)}}{1+e^{\left(19.289-0.628(T)\right)}}$
Mature hardwoods	$P_{pf} = \frac{e^{\left(21.115-0.658(T)\right)}}{1+e^{\left(21.115-0.658(T)\right)}}$

pulses/minute when ≤30° C. We placed VITs at sites in 4 general habitat types reflective of potential birth sites: bare (bare dirt with no surrounding vegetation, exposed to full sunlight; $n = 4$), field (mixed grasses up to 50 cm high with no other surrounding vegetation; $n = 4$), thickets (mixed dense understory and sparse overstory; $n = 4$), and mature hardwoods (sparse understory and mixed dense overstory; $n = 4$) and assigned each site a random number. We randomly assigned each VIT one of the same numbers we used to identify sites and placed each device directly on the ground at the site with the corresponding number. We randomly reassigned transmitters to test sites twice to eliminate bias associated with potential transmitter effects.

We recorded number of pulses/minute emitted by VITs once every 3 hours from 0800 hours to 1600 hours. We considered VITs emitting pulse frequencies indicative of expulsion (i.e., 80 pulses/min) to be properly functioning whereas we classified those emitting pulse frequencies indicative of retention (i.e., 40 pulses/min) as improperly functioning. We obtained air temperatures for dates and times corresponding to our monitoring schedule from the Auburn Airport (KAUO), Auburn, Alabama, which was located approximately 8 km from the study area. We used logistic regression (SAS Institute Inc., Cary, NC) to examine relationships between ambient air temperature and functionality of VITs in each habitat.

RESULTS

Logistic regression indicated an inverse relationship between ambient air temperature and proper functionality of VITs in bare ($P < 0.001$, $\chi^2 = 62.525$, df = 1), field ($P < 0.001$, $\chi^2 = 85.512$, df = 1), thicket ($P < 0.001$, $\chi^2 = 52.555$, df = 1), and mature hardwood ($P < 0.001$, $\chi^2 = 38.743$, df = 1) habitats (Fig. 1; Table 1). Vaginal implant transmitters had high (≥80%) probability of proper functionality in all habitats when ambient air temperatures were ≤22° C; however, performance of VITs was reduced (≤80%) in all habitats when ambient air temperatures exceeded 30° C. Performance of VITs also was influenced by vegetative structure; probability of proper functionality varied among habitats (Fig 1; Table 1). Vaginal implant transmitter performance generally increased along with increased amounts of protection from solar irradiation (e.g., shade) provided by vegetation. Vaginal implant transmitters performed well in thicket and mature hardwood habitats where devices were heavily shaded from direct sun until ambient air temperatures approached the user-defined pulse switch point (i.e., 30° C). However, performance of VITs exposed to full sunlight in bare habitats was reduced at much lower ambient temperatures. For example, VITs in mature hardwood habitats had an approximately 80% chance of proper functionality at 30° C whereas devices in bare habitats were predicted to have an 11% chance of proper functionality. Performance of VITs in field habitats was intermediate between heavily shaded sites and bare sites exposed to full sun.

DISCUSSION

We found that environmental conditions had a measurable influence on performance of VITs. Ambient air temperature was the overriding factor that ultimately determined performance of VITs; however, vegetative characteristics of the habitat surrounding the device also had a strong influence on performance. Current devices likely will perform well if expelled in areas where ambient air temperatures are below the user-defined pulse switch point and habitat conditions provide shade. Performance of VITs will be compromised if they are expelled in areas where air temperatures are above the user-defined pulse switch point and exposed to direct sun.

We programmed our VITs to change pulse frequency between 30° C and 34° C, which is a commonly used setting for many species of ungulates (Seward et al. 2005, Johnstone-Yellin et al. 2006, Saalfeld and Ditchkoff 2007). Although temperature settings are programmable, this setting is used most frequently because the range of practical settings is limited by the internal body temperatures of subject animals and sensitivity of current devices. A decrease in temperature settings provides no benefit because it exaggerates negative effects of warm air temperatures and solar heating on VIT performance. An increase in temperature settings may help moderate the adverse effects of warm environmental conditions. Demarais et al. (1986) observed that rectal temperatures for white-tailed deer, for example, ranged from 38° C to 39.5° C, which is warmer than commonly used settings. Vaginal temperatures likely are similar to reported rectal temperatures; however, knowledge of specific temperatures to which VITs are exposed while implanted may allow for further optimization of settings. Increased temperature settings also may result in increased numbers of false expulsion signals because of greater chances of overlap with internal body temperatures.

Manufactures of VITs should investigate design modifications that reduce error associated with variations in temperature sensitivity between units. More precise temperature switch points would allow for an increase in average temperature at which pulse frequency changes, thereby moderating adverse effects of warm environmental conditions. It may be possible to simultaneously improve precision of temperature switch points among units and reduce negative effects of solar heating by incorporating a reflective or insulating material in VIT housings. Manufacturers may also consider redesigning VITs so that pulse frequency changes are triggered by means other than temperature. Pulse frequency changes triggered by mechanical switches (e.g., a switch associated with silicone wings that emits retention signal when wings are retracted and expulsion signal when wings are fully extended) or switches that rely on electrical circuitry (e.g., a switch associated with electrical ground points on the VIT that emits retention signal when ground points are in contact with the cervix and expulsion signal when not grounded) are alternative designs that potentially reduce negative effects of unfavorable environmental conditions.

Management Implications

We suggest that individuals interested in utilizing currently available VITs consider local climate and vegetative characteristics to evaluate if the devices will meet performance requirements prior to initiating projects. Monitoring efforts in areas where devices potentially are exposed to high temperatures or direct sunlight should target time periods when transmitters have a high probability of proper functionality, such as early morning, late afternoon, and night. Saalfeld and Ditchkoff (2007), for example, were able to achieve high neonate capture rates despite warm ambient air temperatures during daylight hours by adapting their VIT monitoring schedule so that efforts focused on cooler periods of the day.

Acknowledgments

This study was supported by the Alabama Agriculture Experiment Station, Center for Forest Sustainability, and School of Forestry and Wildlife Sciences, Auburn University. We appreciate the assistance of T. Hess during data collection.

LITERATURE CITED

Bishop, C. J., D. J. Freddy, G. C. White, B. E. Watkins, T. R. Stephenson, and L. L. Wolfe. 2007. Using vaginal implant transmitters to aid in capture of mule deer neonates. Journal of Wildlife Management 71:945–954.

Delgiudice, G. D., J. Fieberg, M. R. Riggs, M. C. Powell, and W. Pan. 2006. A long-term age-specific survival analysis of female white-tailed deer. Journal of Wildlife Management 70:1556–1568.

Demarais, S., J. W. Fuquay, and H. A. 1986. Seasonal rectal temperatures of white-tailed deer in Mississippi. Journal of Wildlife Management 50: 702–705.

Garrot, R. A., and R. M. Bartmann. 1984. Evaluation of vaginal implants for mule deer. Journal of Wildlife Management 48:646–648.

Johnson, B. K., T. McCoy, C. O. Kochanny, and R. C. Cook. 2006. Evaluation of vaginal implant transmitters in elk (*Cervus elaphus nelsoni*). Journal of Zoo and Wildlife Medicine 37:301–305.

Johnstone-Yellin, T. L., L. A. Shipley, and W. L. Myers. 2006. Effectiveness of vaginal implant transmitters for locating neonatal mule deer fawns. Wildlife Society Bulletin 34:338–344.

Saalfeld, S. T., and S. S. Ditchkoff. 2007. Survival of neonatal white-tailed deer in an exurban population. Journal of Wildlife Management 71:940–944.

Seward, N. W., D. S. Maehr, J. W. Gassett, J. J. Cox, and J. L. Larkin. 2005. Field searches versus vaginal implant transmitters for locating elk calves. Wildlife Society Bulletin 33:751–755.

Associate Editor: Euler.