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SHORT COMMUNICATIONS

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Effectiveness of Spayvac® for Reducing White-tailed Deer Fertility

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ABSTRACT: Overabundant white-tailed deer (*Odocoileus virginianus*) populations have been reported in many urban and suburban communities across the United States. Large populations of deer can potentially increase the risk of human-wildlife conflicts, such as deer-vehicle collisions, transmission of disease to humans, and vegetation damage. In 2003, efforts to control white-tailed deer numbers were initiated at the National Aeronautical and Space Agency's (NASA) Lyndon B. Johnson Space Center (JSC) in Houston, Texas, using the long-lasting, single-dose contraceptive SpayVac®. Our objectives were to evaluate the effectiveness of SpayVac® for reducing white-tailed deer fertility and determine the partial cost for treatment. Between 2003 and 2004, we monitored 45 adult female deer (34 treated with SpayVac®, 11 controls treated with a placebo). Fawning rate over 2 yr for deer treated with SpayVac® >30 days prior to the rut was 0% (n=31), whereas the fawning rate for control deer was 78% (n=11). Inoculation 1 mo prior to the breeding season was sufficient time to achieve fertility control. We conclude that SpayVac® can effectively reduce the fertility of urban white-tailed deer.

Key words: Fertility control, *Odocoileus virginianus*, population management, urban white-tailed deer.

Overabundant white-tailed deer (*Odocoileus virginianus*) populations have been reported within parks and urban and suburban communities throughout the United States (Porter et al., 1994; Warren, 1997). Deer are often attracted to roadways or right-of-ways because of palatable vegetation, which can increase the potential for deer-vehicle collisions (Conover, 2002). Overabundant deer can potentially increase the incidence of zoonotic diseases (e.g., Lyme disease; Conover, 2002), as well as damage both natural and ornamental vegetation (McShea et al., 1997). Controlling white-tailed deer populations using methods that are socially acceptable, safe, and effective in parks, industrial, and government campuses, and urban and suburban areas is a challenge (Rudolph et al., 2000; Merrill et al., 2003; Rutberg et al., 2004). Lethal methods can be effective, but there are many situations where it is not feasible (Hobbs et al., 2000). Nonlethal methods are often more practical (Lauber and Knuth, 2000), and fertility control has recently been the subject of ongoing interest and research, although it has been applied in few situations (Rutberg et al., 2004). A number of fertility control techniques have been tested on deer, including hormone implants, contragestational agents, surgical procedures, and contraceptive vaccines (Fagerstone et al., 2002). Contraceptive vaccines that use pZP (porcine *zona pellucida*) proteins as antigens have become accepted as safe and effective means of reducing fertility (Rutberg et al., 2004). The practicality of implementing fertility control using most pZP vaccines is severely limited due to the need for multiple booster injections (Miller et al., 2000; Rudolph at al., 2000). Fraker et al. (2002) reported 100% contraceptive efficacy for feral fallow deer (*Dama dama*) treated with a single dose of SpayVac® (ImmunoVaccine Technologies, Inc., Halifax, Nova Scotia, Canada) over 3 yr without boosters.

In 2003, we initiated a trial of SpayVac® to reduce the fertility of the white-tailed deer population at the National Aero-

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nautic Space Administration's (NASA) Lyndon B. Johnson Space Center (JSC). Our objectives were to evaluate the effectiveness of SpayVac® in reducing white-tailed deer fertility and determine the partial costs for treatment.

The JSC is located in southeast Harris County, Texas, USA (29°33′48.90″N, 95°05′17.57″W). The 656-ha facility is located in the Gulf Coastal Plain and Prairies Ecoregion of Texas (Gould, 1975). The JSC consists of improved pasturelands and scattered park-like areas with oaks (*Quercus* spp.), hickories (*Carya* spp.), and pines (*Pinus* spp.) intermixed among roads and buildings, and it is surrounded by urban development. The entire site is enclosed by a 1.8-m chain-link fence topped with three strands of barbed wire that project outward, which restricts deer emigration and immigration. Based on weekly roadside estimates, 167 (±7) deer inhabited the JSC, and annual survival for adult females was 0.91 (±0.06; Hernandez, 2005).

SpayVac® was formulated as described by Brown et al. (1997), except that AdjuVac™ (US Department of Agriculture [USDA] National Wildlife Research Center, Fort Collins, Colorado, USA) replaced Freund's complete adjuvant (Freund, 1956). Porcine *zona pellucida* was isolated from pig ovaries using procedures described by Brown et al. (1997) and Yurewicz et al. (1983). Soluble intact pZP (SIZP) was encapsulated in liposomes containing phospholipon 90 G (Nattermann Phospholipid, Cologne, Germany) and cholesterol in saline. The phospholipids and cholesterol were dissolved in a mixture of methanol/chloroform (1/1; v/v), solvents were removed under reduced pressure using a rotary evaporator and a round-bottom flask containing glass beads to increase surface area. The SIZP was dissolved in saline, and the solution was added to the round-bottom flask containing the phospholipid/cholesterol mixture. The mixture was shaken for 10–20 min to form multilamellar liposomes, while the temperature was maintained at 40 C. A volume of AdjuVac™ equal to the volume of saline was added to the round-bottom flask, and an emulsion was formed by vigorous mixing. A single dose of the vaccine contained liposomes in saline (0.5 ml) with encapsulated SIZP (200 μg) emulsified in AdjuVac™ (0.5 ml). Placebo doses were prepared exactly in the same way, except that the SIZP was omitted.

Weekly road surveys were initiated in 2001 to determine deer population dynamics and potential management strategies (Whisenant, 2003). Female white-tailed deer were captured at JSC between July 2003 and December 2004 using drop nets (Lopez et al., 1998) and portable drive nets (Locke et al., 2004). Deer were physically restrained (no drugs were used) for 10–15 min. All captured adult females were given an injection (intramuscular in the hindquarter) of SpayVac® or the placebo and were permanently marked with an ear tattoo. The deer were fitted with a plastic neck collar (6-cm wide) equipped with a mortality-sensitive radio transmitter (150–152 MHz, Advanced Telemetry Systems, Isanti, Minnesota, USA). Numbered tags were affixed to each side of the neck collar for easy identification.

The cost of materials necessary to capture deer (i.e., nets, t-posts, feeders, feed, etc.), the cost of the vaccine ($50/deer), and vaccine manufacturer's consulting fee were summed to estimate total cost. The sum of costs was divided by the total number of deer trapped to determine cost per deer.

The pregnancy status of experimental deer was monitored weekly from May to October in both 2004 and 2005. They were located visually and via radio-telemetry during weekly road counts (Hernandez, 2005). Marked deer were classified as pregnant, full udder, fawn present, nursing fawn, or none of the previous. Not all marked females were visible from the road surveys; therefore, more intensive searches (3–4 times/wk) were conducted

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on the ground via homing to a female's radio frequency. The female's pregnancy status was classified as previously stated, and the overall pregnancy status of a marked female was based on multiple observations for the duration of the fawning season (i.e., May–October). Based on the pregnancy status of marked deer, we estimated the fawning rate for treated and control deer. Fawn:adult doe ratios of the population from weekly road count data (September–October 2001, 2003, and 2004–2005) were used to determine trends in average number of fawns per adult doe prior to and after treatment. Pretreatment fawn:adult doe ratios (2001 and 2003) were compared to post-treatment fawn:adult doe ratios (2004–2005) using a Kruskall-Wallis test.

Forty-five adult females (34 treated with SpayVac®, 11 controls treated with a placebo) were captured, radio-marked, and monitored. The cost of trapping ($n=45$) and fertility control was estimated to be $350/deer. The fawning rate for all deer treated >30 days prior to the rut was 0% ($n=31$), while the fawning rate for control deer was 78% ($n=11$). Three deer that were treated with SpayVac® during the 2003 rut gave birth to fawns in 2004. One of these did not become pregnant in the second year. The other two were censored from the study, one due to a radio malfunction and the other due to mortality. Five treated deer died during the study (~10%), all apparently from natural causes, and no control deer died. Fawn:adult doe ratios declined significantly post treatment ($P=0.04$; Fig. 1), and we assumed this to be a result of the treatment.

The results show that SpayVac® formulated with AdjuVac™ can be highly effective at reducing the fertility of white-tailed deer for 1–2 yr. We also demonstrated that treatment 30-days prior to the breeding season was sufficient to prevent pregnancy the same year. Fraker et al. (2002) demonstrated a single dose of SpayVac® formulated with Freund's Complete Adjuvant (FCA) was 100 % effective for at least 3 yr in feral fallow deer; however, because FCA can result in adverse reactions in treated animals and positive responses to tests for tuberculosis, FCA is not a desirable constituent of a fertility-control vaccine. The study showed that a single dose of SpayVac® was completely effective for at least 1–2 yr in white-tailed deer.

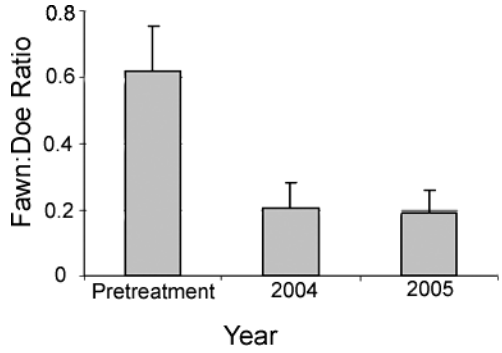


FIGURE 1. Average fawn:adult doe ratios for the Lyndon B. Johnson Space Center deer population pre–SpayVac treatment (2001, 2003) and post–SpayVac treatment (2004–2005; whiskers represent standard error). A statistical difference was identified between pre- and post-treatment years ($P=0.04$).

We summed costs of capturing and treating deer and divided it by the number of deer caught; however, Silvy et al. (1979) reported costs of trapping and tagging deer were lowest when 50% of the total population was trapped. The first few deer trapped accrue the initial costs of trapping (i.e., supplies), whereas the probability of trapping untreated deer after the 50% level becomes increasingly more difficult, which then increases the cost per deer. This study did not factor effort or time into our costs because they were highly variable throughout the study, but Walter et al. (2002) reported labor as the most costly aspect (>60% of total costs) of treating deer with immunocontraceptives. Rutberg et al. (2004) suggested that the practical application of immunocontraceptives may be limited to small enclosed areas or where deer ranges are restricted. Based on our experience at the JSC, we

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believe that large open populations of white-tailed deer would be costly and time consuming and agree that practical administration of immunocontraceptives is likely limited to small, enclosed populations. The long-lasting, single-dose performance of SpayVac® is a major advantage over methods that require that primary and booster inoculations be administered to each deer in the first year, followed by annual boosters in subsequent years (Walter et al., 2002; Rutberg et al., 2004). This eliminates the cost associated with recapturing the same deer over multiple years.

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