October 1993

THE APPLICABILITY AND BIOPOLITICS OF CONTRACEPTIVE TECHNIQUES FOR DEER MANAGEMENT

Robert J. Warren
University of Georgia

Lisa M. White
University of Georgia

THE APPLICABILITY AND BIOPOLITICS OF CONTRACEPTIVE TECHNIQUES FOR DEER MANAGEMENT

ROBERT J. WARREN, Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602

LISA M. WHITE, Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602

ABSTRACT: While regulated public hunting or controlled lethal reduction programs are effective in controlling white-tailed deer *(Odocoileus virginianus),* populations in most areas, increasingly there are settings (e.g., urban and suburban environments) where such programs are either unsafe or publicly unacceptable. Past research with contraceptive techniques in deer have shown these techniques to be either ineffective or infeasible for managerial implementation. Current research with immunocontraceptives show promise as being both effective and feasible for field application. Immunocontraceptive vaccines can be delivered remotely and are highly effective in causing infertility in most treated does. Much more research is needed before these techniques can be used efficiently in contraceptive management programs for deer, however. Immunocontraceptives techniques need to be developed that will not require separate booster vaccinations. Also, field application trials are needed to determine the effectiveness of these techniques at the population level. Finally, effort also is needed on public information and education programs so that both the limitations and potential of these new techniques are understood.

Key words: contraception, deer, fertility control, immunocontraceptives, *Odocoileus virginianus,* white-tailed deer.

Proc. East. Wildl. Damage Control Conf. 6:13-19. 1995.

Overpopulation of white-tailed deer *(Odocoileus virginianus)* has become a significant problem in many areas of the United States. Warren (1991) presents a detailed discussion of the historical causes of this problem, the ecological effects of these overpopulations, and the need for controlling deer populations. Overpopulated deer herds also can cause significant economic losses in the form of crop damage, damage to landscape plantings, and damage to vehicles in deer-vehicle collisions.

In many areas, regulated public hunting is an effective means of controlling deer populations (Behrend et al. 1970). However, in some areas (e.g., national parks, state parks, and urban and suburban areas) hunting is not legally permitted as a method of deer population control. As a result, deer have become a significant and controversial problem in many of these areas. Recently, this controversy has been the focus of numerous national public news articles (e.g., "Deer on Your Doorsteps," *New York Times Magazine*, 28 April 1991; "Deerly Beloved, or Not?" *USA Today*, 22-24 November 1991; "Oh, Deer!" *National Wildlife,* October/November, 1991; "Eastern Wildlife: Bittersweet Success," *National Geographic*, February 1992). Thus, an alternative is needed for controlling free-ranging deer populations in the numerous areas in the United States where public hunting or lethal reductions are not permitted.

Birth control may seem to be a logical alternative method for controlling these deer populations; however, the practical and logistical difficulties of capturing and administering contraceptives has prevented this method from being used by wildlife managers. Contraceptives also must be time and cost efficient for routine use in population management. The purposes of this paper are to review past and current research in the area of deer contraception, to discuss possible areas in which these techniques might be applicable for deer control, and to identify additional areas of needed research in deer contraceptive management. Bomford (1990) and Kirkpatrick and Turner (1991) provide thorough reviews of additional contraceptive technologies that may have potential for application in wildlife. Our purpose here is to concentrate mainly on those contraceptives that have been tested in white-tailed deer.

DELIVERY OF CONTRACEPTIVES TO DEER

Several technologies currently are available for applying contraceptives to deer. Oral delivery methods, whereby a contraceptive steroid is contained within a bait, generally have been ineffective (see section on contraceptive steroids below). Oral delivery methods are being evaluated that may be capable of delivering contraceptive vaccines via a modified live virus or bacterium (see section on immunoinfertility below).

Subcutaneous implants potentially can be an effective contraceptive delivery technique in deer. These implants usually are made from a physiologically inert material, from which the contraceptive steroid is released for up to several years. One major disadvantage of subcutaneous implants is that they require time-consuming and costly capture of individual deer for implantation purposes.

Obviously, delivery technologies that could be administered remotely would be more practical for routine application in deer management. Most immunocontraceptive vaccines can be delivered remotely by using commercially available, self-injecting darts. Remotely delivered darts have several disadvantages, however. They generally are not highly accurate at greater distances. Missed darts often are not recovered and remain in the environment for humans (especially children) to potentially encounter. The metal or plastic darts also often cause tissue trauma in treated deer.

Recent research has evaluated the use of remotely deliverable, intramuscular implants ("biobullets") containing contraceptives. BallistiVet Inc. (Minneapolis, MN) produces an implant "gun" that is capable of remotely injecting a 0.25-caliber, biodegradable "biobullet" at ranges of up to 30 to 40 m. The biobullet is made from compressed food-grade material (hydroxypropyl cellulose) and contains a hollow chamber into which a freeze-dried compound can be placed. After the biobullet is lodged in the muscle, it degrades within a few hours and releases the compound it contains. The biobullet generally is more accurate and causes less tissue trauma than self-injecting darts. The biobullet technique has been used successfully to vaccinate free-ranging bison bon boon in Montana against brucellosis (Davis et al. 1991) and to remotely deliver an immunocontraceptive to free-ranging feral horses *(Equus caballus)* on Cumberland Island, Georgia (Goodloe 1991). The biobullet also has been used successfully to remotely deliver contraceptive vaccines to deer in large enclosures at the University of Georgia (L. M. White, unpubl. data) and at Purdue University (R.K. Swihart, pers. commun.). It also has been used to remotely treat deer with an intramuscular implant containing a contraceptive steroid (see section on contraceptive steroids below).

CONTRACEPTIVE STEROIDS IN DEER

Research has shown that orally administered, synthetic steroid hormones can inhibit ovulation in female deer, but in practice these are not feasible because they require daily oral exposure. Roughton (1979) showed that oral melengestrol acetate (MGA), a synthetic progesterone, was an effective antiovulatory agent in captive white-tailed deer, but daily treatment was required (Roughton 1979). Harder and Peterle (1974) also showed oral treatment or intramuscular injection with diethylstilbestrol (DES), a synthetic estrogen, was not an easily administered method of contraception in deer. Microencapsulation of DES, allowed treatment intervals to be extended to 17 and 30 days, but still required high doses to be effective and was not readily accepted by the deer (Matschke 1977a).

Subcutaneous hormone implants have had limited success in preventing pregnancy in female deer, but these contraceptives require time and cost-inefficient trapping and handling of individual deer. Bell and Peterle (1975) found reduced reproductive rates by use of silastic-silicone rubber tubing implants containing MGA and DES. Matschke (1977b, 1980) examined fertility control in deer with silastic implants of DES and a synthetic progestin (DRC-6246). These implants were considered to have limited application in the field because of the short time span of effective hormone release. Calculated release times for DES were 1-2 years versus 3 years for DRC-6246 (Matschke 1971); however, in a field trial, suppressed reproduction only lasted for 2 years before depletion of the hormone occurred (Matschke 1980).

Plotka and Seal (1989) showed that implants containing MGA provided at least 2 year's infertility when applied to nonpregnant captive deer. However, when applied to five pregnant does during winter, pregnancy was not interrupted and the implants had to be removed, after which one of the treated does died. Plotka and Seal (1989) recommended that pregnant deer not be treated with MGA implants unless pregnancy is first terminated. In is unfortunate that contraceptive steroid implants cannot be used in winter, because at this time deer generally are easiest to bait, capture and treat, all of which would improve the efficiency of applying this technique in the field.

The main limitation of the use of steroid implants as a means of contraception in deer has been the relatively short time of action. Efficient and practical management of deer populations in the absence of regulated hunting requires a contraceptive capable of lasting the reproductive life span of the doe (Matschke 1980). Levonorgestrel (LNG) is an implantable progestin that provides effective, long-term (>5 years) contraception in humans (Diaz et al. 1982).

Contraception of deer for >5 years from one contraceptive treatment may justify the time and cost associated with capturing and treating individual deer, and hence has potential for providing a practical technique for contraceptive management of deer populations.

Despite the potential for this deer contraceptive, two studies with LNG implants in captive white-tailed deer have shown this technique to be ineffective. In the first study, Plotka and Seal (1989) implanted five does with a single homogenous silastic-silicone rod containing 200 mg LNG; three of the five does became pregnant. Plotka and Seal (1989) did not measure LNG concentrations, so the lack of contraception may have been related to the shape and matrix of the silastic implant, all of which can affect steroid hormone release (Robertson et al. 1983).

In the second study with LNG implants in deer, White et al. (1994) used the technique as it is applied in humans, which consists of 216 mg of LNG sealed inside six small silastic-silicone tubes. White et al. (1994) compared six versus nine LNG implants (containing a total of 216 versus 324 mg of LNG) in adult versus fawn does. Fawns were included to determine the effects of LNG implantation on puberty attainment. Despite significant release of LNG from both doses of implants, White et al. (1994) observed that three of five implanted adults and one of two fawns that survived 2 years post-implantation became pregnant. Hence, these researchers did not recommend the use of LNG in deer.

Researchers at Purdue University and the University of California have successfully applied norgestomet (NGM) as a contraceptive in white-tailed deer (R. K. Swihart, pers. commun.) and black-tailed deer *(Odocoileus hemionus)* (Jessupet al. 1993). This synthetic progestin originally was marketed for synchronizing estrus in domestic livestock. Antech Laboratories, Inc. (Champaign, Illinois) has complexed 42 mg of NGM into silastic-silicone rods and loaded it into biobullets for remote delivery purposes (D. J. Kesler, pers. commun.). In both species of deer, NGM was nearly 100% successful in preventing pregnancies, however, it was effective only for 1 year (Jessup et al. 1993, D. J. Kesler, pers. commun.). Therefore, annual treatments would be required to maintain control over deer reproduction. This requirement would limb the applicability of this contraceptive technique primarily to small areas in which substantial control over the deer herd exists.

IMMUNOINFERTILITY IN DEER

A new area of contraception that may be more applicable to deer populations is immunoinfertility. This technique uses an animal's own immune system to disrupt the reproductive system, and has 15 been relatively successful in many species. Indeed, the research results on this new technology for birth control have been so successful and safe that a contraceptive vaccine trial has been tested recently in experimental trials with human females, and with very favorable success (Jones et al. 1988).

Contraceptive vaccines can cause either contraception (immunocontraception) or sterilization (immunosterilization). Immunocontraception involves infertility that is reversible in some cases. Fertility can resume after exposure to the antigen has ceased and the antibody titers decrease (Primakoff et al. 1988). Immunosterilization involves permanent infertility.

Immunoinfertility techniques for contraception or sterilization have numerous advantages over contraceptive steroids that may make them effective and efficient for use in deer. Immunocontraceptives can be delivered remotely, which makes them more feasible for application in the field than methods that require capture and immobilization of individual deer. Also, a protein-based vaccine likely would be deactivated if ingested orally by nontarget organisms in contrast to the persistent tissue residue that often characterize the synthetic steroids. Digestion of the vaccine after oral ingestion likely would prevent unintentional transfer up the food chain to carnivores or humans.

The most likely antigens for use in vaccines are proteins involved in fertilization. One immunocontraceptive that has been tested in wild species is based on developing antibodies to the zona pellucida (ZP). The zp is a series of glycoproteins surrounding the ovum that is important in sperm-egg binding during fertilization. Injections with immunocontraceptives containing ZP cause the female to produce antibodies to ZP, which then interfere with normal fertilization. Turner et al. (1992) successfully used porcine and pellucida (PZP) antigen in an immunocontraceptive for white-tailed deer. Their vaccine was delivered remotely; however, multiple booster injections were required. This requirement limits the practicality of using this contraceptive vaccine in free-ranging deer populations. Recent advancements in research with PZP have included microencapsulation of the booster vaccinations so that only one vaccination per year is required; the booster vaccines are microencapsulated for release over a period of weeks or months post-injection (J. F. Kirkpatrick, pers. commun.).

Several different spermatozoa proteins also are being considered for use in anti-sperm contraceptive vaccines (Naz and Menge 1990). Anti-sperm vaccination may cause infertility in the male or female. In the male, anti-sperm antibodies may cause an autoimmune response to the sperm, thus resulting in infertility (Mathur et al. 1988). Treating bucks in a free-ranging deer population with an anti-sperm vaccine would have limited effect on the reproductive rate of the herd, because deer are polygynous breeders. However, applying a anti-sperm vaccine may be more practical if males and females did not have to be distinguished prior to treatment.

In the female, anti-sperm antibodies may cause agglutination of sperm (reviewed in Shulman 1986), or reduced penetration of sperm through the cervical mucus (Clarke 1988), or altered sperm binding to the ZP (Naz et al. 1992). Anti-sperm vaccines also may be "self boosted" (i.e., additional exposure and boosting of the immunity against sperm may occur with each insemination). Some women with spontaneous sperm-antibody titers have reduced titers following the use of condoms, which probably function to prevent "boosting" from sperm in the vagina (reviewed in Shulman 1986). Thus, if anti-sperm vaccines are "self-boosting," they may have more practicality for field implementation than multiple booster vaccinations of anti-ZP vaccines.

Very little research exists on the use of anti-sperm vaccines in deer. White et al. (1993) presented preliminary data on an anti-sperm vaccine for deer. They developed anti-sperm vaccines using sperm plasma membranes from deer, bull, and boar sperm. These vaccines were ejected into adult does, from which blood samples were collected for antibody titer analysis. High anti-sperm antibody titers occurred in does injected with anti-sperm vaccines made from all species tested. However, antibody recognition of deer sperm was greatest in those does injected with either deer or boar sperm. The high antibody titers persisted for a period of at least 11 months post-immunization. The does treated in this preliminary trial became pregnant, but future work with a purified form of this vaccine may have a greater chance of causing infertility (L. M. White, unpubl. data).

Research is planned at the Denver Wildlife Research Center to develop an oral delivery method for immunocontraceptive vaccines (R. D. Thompson, pers. commun.). This research is in the early stages of development. Conceptually, a genetically modified bacterium or virus would be used as a live vector to orally deliver a genetically engineered immunocontraceptive vaccine to deer. Similar technologies have been used recently to deliver orally effective rabies vaccines to wildlife populations (Wandeler et al. 1988). Obviously, such a contraceptive technology would greatly improve the cost and time efficiency of applying immunocontraceptives to free-ranging deer populations. A number of serious concerns exist regarding the potential risk of using such a technology in the wild, however. For example, nontarget species, including humans, might be at risk of being exposed to these contraceptive vaccines. In addition, controlling the spread of the bacterium or virus to other deer populations may be difficult. Much more research obviously is necessary before this technology can be considered even for field testing.

CONTRACEPTIVE SEARCH RECOMMENDATIONS

Past research has shown that several contraceptive techniques are effective in individually treated deer. What is lacking in the literature is documentation of the effectiveness of contraceptive management techniques at the population level. Despite their success in captive deer, many of these methods may be infeasible to implement in free-ranging deer populations, or they may be unsuccessful in controlling the **population**. In other words, eliminating reproduction in treated individuals may not control a deer population. Reduced reproduction by those does treated with contraceptives may provide greater chances for survival to those fawns that are born to the does in a population that escaped treatment with the contraceptive. Additionally, any reductions in a particular herd's density because of reduced reproductive effort could be offset by immigration of deer from areas surrounding the treated area. Of course, this problem could be rectified to a great extent by erecting a deer-proof fence. Thus, there is a critical need for controlled research to evaluate the effectiveness of deer contraceptives at the population level. Changes in the number and composition of most wildlife populations are dynamic and occur as the result of a multitude of factors, only one of which is reproduction. Deer population control must be considered and evaluated within its complete ecological context.

Use of a practical, highly effective contraceptive implant for white-tailed deer would ideally be administrable in prepubertal fawns. When treating or trapping deer, fawns often are encountered along with adult does. Treating fawns with an infertility agent when they are easily caught or treated would increase the efficiency of a contraceptive management program. Further research evaluating the use of contraceptives in prepubertal fawns may increase the practicality of a contraceptive treatment program in free-ranging white-tailed deer. A related concern is the safety of a particular contraceptive to young bucks that may not be distinguishable from does in remote delivery programs.

One other area of needed research is to evaluate the effects of contraceptive management techniques on deer behavior and population dynamics. It is quite possible that by treating does with contraceptives, wildlife biologists may extend the rutting period. Does that fail to conceive can continue estrous cycling activity for up to 7 months (Knox et al. 1988). Thus, treating does with contraceptives may extend the breeding season, which may induce bucks to continue to be highly territorial and reproductively active. If this behavioral change occurs, it is possible that bucks in a population could experience substantially greater over-winter mortality rates than under conditions of a shorter, more normal breeding season.

Finally, research is needed to determine the extent to which contraceptive vaccines may be effective after ingestion by nontarget organisms, including humans. Immunocontraceptives will not be approved for routine field implementation in deer management programs until these potential secondary effects are documented as being insignificant environmentally.

BIOPOLITICS

Some concerns exist as to whether contraceptive techniques may eventually replace regulated hunting for controlling deer herds. Lethal shooting by hunters or sharpshooters likely will continue to be the preferred deer population management alternative in those areas where such techniques are safe and acceptable. It is doubtful that contraceptive techniques will be cost effective or recommendable for widespread application in free-ranging deer herds. The actual contraceptive agents may be economical, but the personnel and operating expenses associated with delivering contraceptives to significant proportions of individuals in a deer herd likely will be cost prohibitive. This concern also may apply in urban and suburban areas where deer herds are fenced or otherwise isolated from other natural habitats.

It is important that wildlife biologists effectively communicate the limitations of contraceptive techniques to the public, politicians, and the media. Contraceptives provide a potential technique that wildlife biologists can use in situations where other traditional methods of population control may not be feasible; however, they have several limitations. Public sentiment likely will be the primary catalyst that will mandate the use of contraceptives in some areas. Unfortunately, these areas are increasing in their occurrence m the eastern United States as more urban and suburban development occurs. These are the challenges that will face wildlife biologists in the next few decades. Wildlife biologists have an obligation to consider all possible tools and techniques for use in deer population management, including contraceptives.

LITERATURE CITED

Behrend, D. F., G. F. Mattfield, W. C. Tierson, and J. E. Wiley, III. 1970. Deer density control for comprehensive forest management. J. For. 68:695-700.

Bell, R. L., and T. J. Peterle. 1975. Hormone implants control reproduction in white-tailed deer. Wildl. Soc. Bull. 3:152-156.

Bomford, M. 1990. A role for fertility control in wildlife management. Bull. No. 7, Bureau of Rural Resources, Australian Government Publ. Serv., Canberra. 50pp.

Clarke, G. N. 1988. Lack of correlation between the immunobead test and the enzyme-linked immunosorbent assay for sperm antibody detection. Amer. J. Reprod. Immunol. 18:44-46.

Davis, D. 5., J. W. Templeton, T. A. Ficht, J. D. Huber, R.D. Angus, and L. G. Adams. 1991. *Brucella abortus* in bison. II. Evaluation of Strain 19 vaccination of pregnant cows. J. Wildl. Dis. 27:258-264.

Diaz, 5., M. Pavez, P. Miranda, D. N. Robertson, I. Sivin, and H. B. Croxatto. 1982. A five-year clinical trial of levonorgestrel silastic implants ($NORPLAN_{TM}$). Contraception 25:447-456.

Goodloe, R. B. 1991. Immunocontraception, genetic management, and demography of feral horses on four eastern U.S. barrier islands. Ph.D. Dissert., Univ. of Georgia, Athens. 150 pp.

Harder, J. D., and T. J. Peterle. 1974. Effect of diethylstilbestrol on reproductive performance of white-tailed deer. J. Wildl. Manage. 38:183-196.

Jessup, D. A., N. K. Jacobsen, and D. J. Kesler. 1993. Remotely delivered and reversible contraception of black-tailed deer by norgestomet ballistic implants. Proc. Annu. Conf. Wildl. Dis. Assoc. 42:39 (Abstract).

Jones, W. R., S. R. Judd, R. M. Y. Ing, J. Powell, J. Bradley, E. H., Denholm, U. W. Mueller, P. D. Griffin, and V. C. Stevens. 1988. Phase I clinical trial of a World Health Organization birth control vaccine. Lancet 8598:1295-1298.

Kirkpatrick, J. F., and J. W. Turner, Jr. 1991. Reversible contraception in nondomestic animals. J. Zoo Wildl. Med. 22:392-408.

Knox, W. M., K. V. Miller, and R. L. Marchinton. 1988. Recurrent estrous cycles in white-tailed deer. J. Mammal. 69:384-386.

Matschke, G. H. 1977a. Microencapsulated diethylstilbestrol as an oral contraceptive in white-tailed deer. J. Will. Manage. 41:87-91.

_____. 1977b. Fertility control in white-tailed deer by steroid implants. J. Wildl. Manage. 41:731-735.

_____. 1980. Efficacy of steroid implants in preventing pregnancy in white-tailed deer. J. Wildl. Manage. 44:756-758.

Mathur, 5., L. Chao, J. M. Goust, G. T., Milroy, C. Woodley-Miller, J. Z. Caldwell, F. Daru, and H. O. Williamson. 1988. Special antigens on sperm from autoimmune infertile men. Amer. J. Reprod. Immunol. 17:5-13.

Naz, R. K., C. Brazil, and J. W. Overstreet. 1992. Effects of antibodies to sperm surface felon antigen-1 on human sperm-zona pellucida interaction. Fertil. Steril. 57:1304-1310.

_____, and A. Menge. 1990. Development of antisperm contraceptive vaccine for humans: why and how? Human Reprod. 5:511-518.

Plotka, E.D., and U.S. Seal. 1989. Fertility control in female white-tailed deer. J. Wildl. Dis. 25:643-646.

Primakoff, P., W. Lathrop, L. Woolman, A. Cowan, and D. Myles. 1988. Fully effective contraception in male and female guinea pigs immunized with the sperm protein PH-20. Nature 335:543-546.

Robertson, D. N., I. Sivin, H. A. Nash, J. Braun, and J. Dinh. 1983. Release rates of levonorgestrel from silastic® capsules, homogenous rods and covered rods in humans. Contraception. 27:483-495.

Roughton, R.D. 1979. Effects of oral melengestrol acetate on reproduction in captive white-tailed deer. J. Wildl. Manage. 43:428-436.

Shulman, S. 1986. Sperm antigens and autoantigens: effects on fertility. Am. J. Reprod. Imnnunol. 10:82-89.

Turner, J. W., I. K. M. Liu, and J. F. Kirkpatrick. 1992. Remotely delivered immunocontraception in captive white-tailed deer. J. Wildl. Manage. 56:154-157.

Wandeler, A. I., S. Capt, A. Kappeler, and R. Bauser. 1988. Oral immunization of wildlife against rabies: concept and first field experiments. Rev. Infect. Dis. 10:5649-5653.

Warren, R. J. 1991. Ecological justification for controlling deer populations in eastern national parks. Trans. North Amer. Wildl. Natur. Resour. Conf. 56:56-66.

White, L. M., P. M. Smith, C. C. Miller, R. A. Fayrer-Hosken, and R. J. Warren. 1993. Development of an anti-sperm immunocontraceptive for white-tailed deer *(Odocoileus virginianus).* Theriogenology 39:339 (Abstract).

_____, R. J. Warren, and R. A. Fayrer-Hosken. 1994. Levonorgestrel implants as a contraceptive in captive white-tailed deer. J. Wildl. Dis. 30:(In Press).