Managing Prairie Dogs by Managing Plague: A Vaccine for the Future?

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ABSTRACT: The Black-footed Ferret Recovery Implementation Team Executive Committee is conducting a project to develop, and (hopefully) eventually implement, a plague vaccination program for prairie dogs. The project is a component of the Western Association of Fish and Wildlife Agencies Grasslands Conservation Initiative. An effective, field-worthy vaccine against plague could be the biggest breakthrough in recovery efforts for the black-footed ferret since the 1981 rediscovery of wild ferrets near Meeteetse, Wyoming. If proven efficacious, the vaccine could help agencies and stakeholder cooperators maintain specific populations of prairie dogs at robust levels, thus enhancing range-wide conservation of those species, as well recovery of the ferret, while enabling control of other prairie dog populations to resolve site-specific agricultural and human health concerns. The results of laboratory and field-testing in the early stages of developing this vaccine are preliminary but mostly encouraging. A plan for broad-scale application is being developed for possible use when testing has been completed and (if warranted) the vaccine is registered for governmental use. An overview of all aspects of the project is discussed.

KEY WORDS: black-footed ferret, conservation, *Cynomys* spp., disease management, endangered species, *Mustela nigripes*, prairie dog, sylvatic plague, vaccine, *Yersinia pestis*

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INTRODUCTION

The Black-footed Ferret Recovery Implementation Team (BFFRIT; hereafter, Executive Committee) and Western Association of Wildlife Agencies (WAFWA) Sylvatic Plague Vaccine Project (SPV project) is a collaborative effort among (presently) 22 Federal, State, and Tribal agencies and nongovernmental organizations (USFWS BFFRIT 2011, WAFWA 2014). The project is exploring potential use of an experimental oral sylvatic plague vaccine (Abbott et al. 2012) to: 1) enhance purposeful control and conservation of prairie dogs (*Cynomys* spp.); 2) enable success in recovery of the threatened Utah prairie dog (*C. parvidens*) and the endangered black-footed ferret (*Mustela nigripes*); and 3) diminish the extent to which various other western grassland species and shrub-steppe are imperiled.

THE PROBLEM

In the past 100 years, North American prairie dogs and black-footed ferrets have been affected severely by plague, a zoonotic disease caused by the bacterium *Yersinia pestis* (USFWS 2013). Three forms of plague exist: bubonic, septicemic, and pneumonic. In nature, plague is transmitted among hosts (rodents) by vectors (infected fleas) (Poland and Barnes 1979). Typically, humans get plague from infected fleas but the pneumonic form can also be spread from human to human. In humans, the most common form is bubonic plague. In wild mammals, the disease is known as sylvatic plague ("sylvatic" referring to occurrence in the wild).

Plague probably originated in China, where it first emerged more than 2,600 years ago (Morelli et al. 2010). Its first appearance on mainland North America occurred in San Francisco and in New York City in 1899 (Link 1955), probably as a result of infected rats and fleas arriving on ships sailing from the Orient, via Hawaii (Link 1955, Chase 2003, Orent 2004). Ironically, 1900 was known on the Chinese calendar as the "Year of the Rat" and residents of San Francisco's Chinatown were the first known plague victims in North America during the 1900 outbreak (Link 1955, Chase 2003). Outbreaks also occurred in other port cities, including Seattle, Los Angeles, and New Orleans. Small epidemics followed in 1907-1908, 1914, and 1920, and by the mid-1900s plague was persistent in America.

Since its arrival in North America, plague has contributed to massive population declines of prairie dogs and near extinction of black-footed ferrets; both are especially susceptible. Plague has also caused human fatalities in western regions in which prairie dogs occur, including Arizona, Colorado, New Mexico, and Utah (four high-risk states) (Barnes 1990, Butler 2009). Plague outbreaks

among prairie dogs are unpredictable but can lead to mortality rates nearing 100% (Cully et al. 2010). Local recovery can be dependent on immigration from nearby prairie dog sites, if such occur. Black-footed ferrets also suffer from loss of their prey base (prairie dogs) which contributed to near extinction of the ferret in the late 1900s (Biggins et al. 2011).

Until now, the primary method to combat plague has been application of insecticidal dust in prairie dog burrows to kill fleas, the vector for plague (Biggins et al. 2010). Dusting is, however, labor intensive, costly (up to $68.91 per hectare; Griebel 2009) and relatively short-lasting. It is logistically difficult to apply and sustain during inclement weather and in very large colonies and complexes over multiple years.

Given the costs and inherent sociopolitical challenges at each prairie dog colony or complex, development of large numbers of black-footed ferret recovery sites sufficient to offset periodic losses due to plague is not realistic with available tools. Consequently, an effective, field-worthy vaccine could be a valuable complement to assist in long-term management and species recovery.

A POTENTIAL SOLUTION

A candidate vaccine (dubbed "sylvatic plague vaccine" or "SPV") has been developed by scientists at the U.S. Geological Survey (USGS) National Wildlife Health Center, Madison, WI, and the University of Wisconsin, Madison, WI (Osorio et al. 2003). Its effectiveness under field conditions is uncertain but preliminary laboratory testing indicates the SPV, administered orally by vaccine-laden baits, is effective in several species of prairie dogs and might also be effective for a variety of non-target rodents (Rocke et al. 2008, Rocke et al. 2010). Although it is still experimental, the vaccine shows great promise as another tool for pre-emptively controlling plague at specific sites. Even so, SPV is unlikely to replace dusting as a means of controlling sylvatic plague. More likely, the two methods could be used in combination or in rotation, with reliance on one or the other when site-specific circumstances warrant doing so.

Targeted application of SPV in key areas could contribute to more stability in targeted prairie dog populations (Abbott et al. 2012). Clearly, if sufficiently effective, SPV could be the biggest breakthrough in recovery efforts for the black-footed ferret since rediscovery of wild ferrets in 1981, near Meeteetse, WY. It could help agencies and stakeholders maintain specific populations of prairie dogs (and black-footed ferrets) at robust levels, thus enhancing their conservation range-wide, while also enabling control of other prairie dog populations to resolve site-specific agricultural and human health concerns. It could yield huge economic and environmental benefits from reduced costs of ferret and prairie dog conservation and recovery efforts and decreased restrictions on development and agriculture in areas with prairie dogs. Urban areas, national parks, military lands, tribal lands, and private lands could all benefit from use of an effective plague vaccine.

As noted below, more extensive testing, data analysis, and more licensing-related reviews are needed to demonstrate SPV efficacy and cost-effectiveness sufficient to encourage broad-scale production and eventual use by government applicators. Prior to 2011, progress toward that end was precluded by collective inability to ensure timely completion of the remaining steps in developing this technology, including securing funding for the last stages of vaccine testing, mass production, and delivery to natural resource managers for field use. Key agency staff members were committed to the significant possibilities but were heavily burdened by short-term and other agency priorities. However, the SPV project is now surmounting those obstacles, and prospects for the future seem bright.

PROJECT OVERVIEW

The SVP project formally began in December 2010, when the BFFRIT Executive Committee committed to helping complete development of the SPV. To guide the new project, the U.S. Fish and Wildlife Service authorized the Executive Committee to establish an SPV Subcommittee of the BFFRIT. The SPV Subcommittee (hereafter Subcommittee) was created in December 2010 as a sylvatic plague vaccine entity, with several Work Groups. To ensure compliance with the Endangered Species Act of 1973 and the Federal Advisory Committee Act, in December 2011 the USFWS chartered the SPV effort as a Subcommittee of the BFFRIT. The Subcommittee includes representatives from Federal and State agencies, Tribal agencies, and nongovernmental organizations that are active in the Executive Committee. As the project unfolds, membership will be expanded to include more individuals that have relevant expertise and/or interest.

At BFFRIT Executive Committee request, Directors of WAFWA's State Wildlife Agency members unanimously endorsed the SPV project in January 2011, as a component of their Grasslands Conservation Initiative (GCI). The WAFWA grasslands initiative operates under auspices of a multi-state, multi-agency Memorandum of Understanding that WAFWA approved in January 2006 and renewed in January 2011 (WAFWA 2011). WAFWA's role in the project is to: a) cooperate with the BFFRIT Executive Committee in overseeing SPV work, b) serve as "banker" for project funds (WAFWA's standard overhead rate of 5% applies), and c) contract for a Project Coordinator. The Project Coordinator was selected in February 2011 and facilitates the effort under guidance from the BFFRIT Executive Committee Chair, two WAFWA State and Federal Sponsors, the WAFWA GCI Coordinator, and (most directly) the two Co-Chairs of the SPV Subcommittee. The Executive Committee and WAFWA agreed that a dedicated Project Coordinator would be essential to success as cooperators worked toward the transition from laboratory research to field testing and eventual application by wildlife and land management agencies that are responsible for purposeful prairie dog and black-footed ferret conservation.

The SPV Subcommittee itself consists of Work Groups, each led by a Chair approved by the Subcommittee Co-Chairs. Work Groups are anticipated to come and go as necessary to meet current needs, but at this time four exist: Science, Compliance, Management, and Technology Transfer. The Subcommittee also participates in

BFFRIT Conservation, Information/Outreach, and Management subcommittees and the Executive Committee's *ad hoc* Funding Work Group.

Project oversight is rigorous. The Coordinator reports on progress to the BFFRIT Executive Committee at its summer and winter meetings and to WAFWA Directors at each WAFWA Winter Business Meeting and Annual (summer) Conference. The Executive Committee Chair, the two WAFWA State and Federal Sponsors, the two SPV Subcommittee Co-Chairs (with input from the Subcommittee), and the WAFWA CGI Coordinator review the project each December to ensure that progress is sufficient to warrant continuation and to modify the project as necessary if it continues. WAFWA acts on the Executive Committee recommendations in January each year and then, if appropriate, renews the annual Coordinator contract in February.

SUBCOMMITTEE (PROJECT) OBJECTIVES

The Executive Committee has established four primary objectives for the SPV Subcommittee: 1) help complete development and delivery of the SPV management tool; 2) resolve critical needs that pertain to development and on-the-ground delivery of the SPV management tool; 3) build a robust interagency foundation for continued use of the SPV management tool to support black-footed ferret recovery in targeted locations by suppressing plague in prairie dogs and perhaps in other grassland species; and 4) develop national strategies to institutionalize use of the SPV management tool as an integral component of prairie dog and black-footed ferret conservation and recovery.

Toward those ends, the Subcommittee will help define techniques for use of SPV in the field, establish an interagency forum for deciding where and when the vaccine will be used, and identify approaches to sharing the cost of implementing this management tool across the appropriate agencies. The work will primarily be conducted in three stages.

- Phase 1: Laboratory trials; field safety trials (Tripp et al. 2014); compliance with the National Environmental Policy Act (USGS NWHC 2012) and any other applicable regulations; and Federal approval for experimental (government-only) use. This phase was completed in 2012 (Brand 2013).
- Phase 2: Field efficacy trials, data analysis, and final Federal registration. This phase began in 2013 at 29 paired sites in 7 states and will be completed in 2016-2017. The total number of sites involved is expected to be 32, in 8 states plus Mexico, covering all 5 species of prairie dogs.
- Phase 3: [If warranted] Range-wide operational application and adaptive management to refine best use practices. Contingent on results and available funding, this phase could begin as early as 2016.

FUNDING AND COSTS

This is a major undertaking; appreciable resources are needed to complete it. Agencies participating in the SPV Subcommittee voluntarily share responsibility with the BFFRIT Executive Committee for developing the funds necessary for project success. The Executive Committee solicits funding from individual WAFWA states, Federal agencies, and other sources that have vested interests in the SPV as a means of achieving prairie dog and black-footed ferret conservation goals. WAFWA itself does not provide funding but helps secure grants, and member agencies contribute matching funds or in-kind contributions for grants that require such.

The current project annual costs for administration, coordination, vaccine and bait production, field testing and data collection, and laboratory and data analyses exceed $500,000 per year (including in-kind contributions). Costs and the next year's budget are subject to review each December during the Coordinator's progress report to the BFFRIT Executive Committee. WAFWA Directors have the opportunity to review and concur with the Executive Committee recommendation in the January WAFWA Winter Business Meeting.

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LITERATURE CITED

Abbott, R. C., J. E. Osorio, C. M. Bunck and T. E. Rocke. 2012. Sylvatic plague vaccine: A new tool for conservation of threatened and endangered species? EcoHealth 9:243-250.

Barnes, A. M. 1990. Plague in the U.S.: Present and Future. Proc. Vertebr. Pest Conf. 14:43-46.

Biggins, D. E., J. L. Godbey, K. L. Gage, L. G. Carter, and J. A. Montenieri. 2010. Vector control improves survival of three species of prairie dogs (*Cynomys*) in areas considered enzootic for plague. Vector-Borne and Zoonotic Dis. 10:17-26.

Biggins, D. E., T. M. Livieri, and S. W. Breck. 2011. Interface between black-footed ferret research and operational conservation. J. Mammal. 92: 699-704.

Brand, C. J. 2013. Wildlife mortality investigation and disease research: Contributions of the USGS National Wildlife Health Center to endangered species management and recovery. EcoHealth 10:446-454.

Butler, T. 2009. Plague into the 21st Century. Clin. Infect. Dis. 49:736-742.

Chase, M. 2003. The Barbary Plague. Random House, Inc., New York, and Random House of Canada, Toronto. 276 pp.

Cully Jr., J. F., T. L. Johnson, S. K. Collinge, and C. Ray. 2010. Disease limits populations: Plague and black-tailed prairie dogs. Vector-borne and Zoonotic Dis. 10:7-15.

Griebel, R. L. 2009. Wall Ranger District 2009 Plague Management Report. Nebraska National Forest, Buffalo Gap National Grassland, Wall Ranger District, Wall, SD. 13 pp.

Link, V. B. 1955. A history of plague in the United States of America. Public Health Monograph No. 26. 12 pp.

Morelli, G., Y. Song, C. J. Mazzoni, M. Eppinger, P. Roumagnac, D. M. Wagner, M. Feldkamp, B. Kusecek, A. J. Vogler, Y. Li, Y. Cui, N. R. Thomson, T. Jombart, R. Leblois, P. Lichtner, L. Rahalison, J. M. Petersen, F. Balloux, P. Keim, T. Wirth, J. Ravel, R. Yang, E. Carniel, and M. Achtman. 2010. *Yersinia pestis* genome sequencing identifies patterns of global phylogenetic diversity. Nature Genetics 9:1140-1143.

Orent, W. 2004. Plague. Free Press, New York, NY. 276 pp.

Osorio, J. E., T. D. Powell, R. S. Frank, K. Moss, E. J. Haanes, S. R. Smith, T. E. Rocke, and D. T. Stinchcomb. 2003. Recombinant raccoon pox vaccine protects mice against lethal plague. Vaccine 21:1232-1238.

Poland, J. D., and A. M Barnes. 1979. Plague. Pp. 515-559 *in*: J. H. Steele, H. Stoenner, W. Kaplan, and M. Torten (Eds.), CRC Handbook Series in Zoonoses. CRC Press, Boca Raton, FL.

Rocke, T. E., S. R. Smith, D. T. Stinchcomb, and J. E. Osorio. 2008. Immunization of black-tailed prairie dog against plague through consumption of vaccine-laden baits. J. Wildl. Dis. 44:930-937.

Rocke, T. E., N. Pussini, S. R. Smith, J. Williamson, B. Powell and J. E. Osorio. 2010. Consumption of baits containing raccoon pox-based plague vaccines protects black-tailed prairie dogs (*Cynomys ludovicianus*). Vector-Borne and Zoonotic Dis. 10:53-58.

Tripp, D. W., T. E. Rocke, S. P. Streich, N. L. Brown, J. Rodriguez-Ramos Fernandez, and M. W. Miller. 2014. Season and application rates affect vaccine bait consumption by prairie dogs in Colorado and Utah, USA. J. Wildl. Dis. 50(2):224-234.

U.S. Fish and Wildlife Service. 2013. Recovery plan for the black-footed ferret (*Mustela nigripes*). U.S. Fish and Wildlife Service, Denver, CO. 157 pp.

USFWS BFFRIT (U.S. Fish and Wildlife Service Black-footed Ferret Recovery Implementation Team). 2011. Who we are. Webpage.

USGS NWHC (U.S. Geological Survey, National Wildlife Health Center). 2012. Environmental assessment: Field studies to assess the safety of sylvatic plague vaccine in prairie dogs and non-target animals. U.S. Geological Survey, National Wildlife Health Center, Madison, WI. 59 pp.

WAFWA (Western Association of Fish and Wildlife Agencies). 2011. Western grasslands initiative strategic plan. Western Association of Fish and Wildlife Agencies, Laramie, WY. 32 pp.

WAFWA (Western Association of Fish and Wildlife Agencies). 2014. About WAFWA. Webpage.