12-2022

# One Health in action: flea control and interpretative education at Badlands National Park

David Eads

Lindsey Buehler

Anne Esbenshade

Jason Fly

Evan Miller

*See next page for additional authors*

## Authors
David Eads, Lindsey Buehler, Anne Esbenshade, Jason Fly, Evan Miller, Holly Redmond, Emily Ritter, National Park Service, Sasha Wittmann, Paul Roghair, and Eddie Childers

SHORT COMMUNICATION



# One Health in action: flea control and interpretative education at Badlands National Park

David Eads[1✉], Lindsey Buehler[2,3], Anne Esbenshade[3], Jason Fly[3], Evan Miller[3], Holly Redmond[3], Emily Ritter[3], Caitlyn Tynes[3], Sasha Wittmann[3], Paul Roghair[3], and Eddie Childers[3]

[1]*U.S. Geological Survey, Fort Collins Science Center, CO, U.S.A., deads@usgs.gov*
[2]*Prairie Wildlife Research, WI, U.S.A.*
[3]*National Park Service, Badlands National Park, SD, U.S.A.*

One Health involves interdisciplinary collaboration to improve, protect, and preserve the health of humans, wildlife, and ecosystems, and advocates for unified approaches to One Health challenges (Buttke et al. 2015). Here, we focus on a One Health challenge of nearly global distribution: *Yersinia pestis*, the flea-borne bacterial agent of plague. The bacterium poses a significant risk to humans and wildlife, causing social strife in some regions and transforming ecosystems (Eads and Biggins 2015). The conservation implications are profound in the western United States, where *Y. pestis* was first introduced in 1900. Considerable effort is devoted to plague mitigation, sometimes for human or wildlife health purposes separately. We present a synergy between plague mitigation for human and wildlife health.

Most human plague cases are linked with epizootics among rodents. Public education assists in increasing awareness of *Y. pestis*, transmission routes, and rodent die-offs, allowing people to alter their behavior in ways to reduce exposure. Insecticides can be used to protect humans and wildlife against fleas (Eisen et al. 2021). Including One Health messages can improve public health outcomes and conservation ethics and support (Lu et al. 2016). Our research combines One Health messaging and flea control measures under a collaborative framework.

Specifically, at Badlands National Park (BNP), SD, we sought to identify a plague mitigation strategy that could (a) address both human and wildlife risk during peak human visitation, (b) maintain wildlife populations, and (c) reduce human risk of insecticide exposure. Our framework included the following activities on colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) used by BNP visitors for wildlife viewing, photography, and camping (Figure 1). First, we compared prairie dog flea burdens on habitats treated with fipronil grain bait, a systemic insecticide product, and prairie dog flea burdens on habitats left untreated as experimental baselines. Second, we compared flea abundance in prairie dog burrows in the same habitats. The data generated during this study are available as a USGS data release (Eads 2022).

We tested a U.S. Environmental Protection Agency approved grain bait laced with 0.005% fipronil by weight (Scimetrics Limited Corp., Wellington, CO, EPA Reg. No. 72500-28). In prior studies, fipronil grain was applied to prairie dog colonies in February-March (Poché et al. 2017) or July-September (Poché et al. 2020, Eads et al. 2019, 2020). In the February-March studies, three consecutive treatments were completed 0, 7, and 21-days post-treatment. The July-September studies involved single applications. Here, we test single applications in February or May.

We tested fipronil grain on two prairie dog colonies: Colony A (named Roberts, ~365 ha) in 2020 and Colony B (named Sage Creek Campground, ~9 ha) in 2021. Colony A is mostly used by BNP visitors for wildlife viewing and photography. Colony B includes 22 campsites and is heavily used for camping, hiking, and horseback riding, which places visitors near prairie dogs and their burrows, and potential questing fleas.

To assess on-host flea numbers (in 2020 and 2021), we live-trapped prairie dogs, anesthetized them, and combed their bodies for fleas (Eads et al. 2019). Detected fleas were counted and placed back on the prairie dogs from which they were collected to reduce a potential removal effect. To assess off-host flea numbers (in 2021), we swabbed burrows with 15 × 15 cm flannel cloth, a common approach for flea surveillance on prairie dog colonies (Eads 2017). Detected fleas were counted and returned to the burrow from which they were swabbed.

During 15-16 and 21-22 February 2020, ¼ cup of fipronil

Figure 1. Live-trapped black-tailed prairie dog (burrow opening visible to left of trap door) at the campground portion of Colony B, Badlands National Park, South Dakota, June 2021. Covered picnic area, camping tents, and vehicles visible in the background. Photo credit: Holly Redmond.

grain was placed at each prairie dog burrow at Colony A ($n$ = 34,318 burrows). We assessed on-host flea burdens on three 1.44 ha sites at Colony A and three 1.44 ha sites at a separate non-treated colony, with sampling 129-138 days post-treatment (alternating between Colony A and the non-treated colony daily).

On 11 May 2021, a 4.86 ha portion of Colony B was treated with fipronil grain at ¼ cup per burrow (537 burrows). We assessed on-host flea burdens 25-27, 38–39, and 105-107 days post-treatment and swabbed burrows for fleas 27-28 and 102-103 days post-treatment, with sampling occurring simultaneously on the treated campground and a separate non-treated 3.89 ha portion of the same colony.

In 2020 we failed to comb any fleas from 43 prairie dogs at Colony A vs 48 fleas from 28 prairie dogs at the non-treated colony. We analyzed on-host flea abundance using generalized linear models, accounting for over-dispersion (Lindén and Mäntyniemi 2011) using a negative binomial error distribution ('glm.nb', R version 3.6.1). The single February treatment was effective in flea control for at least 4-5 months (z-test $P < 0.001$).

In 2021, we combed eight fleas from 194 prairie dogs on the treated (campground) portion of Colony B vs 50 fleas from 41 prairie dogs on the non-treated portion. We did not find fleas in swabs from 200 burrows on the campground vs 193 fleas from 200 burrows on non-treated habitat. We combined the data and used generalized linear models to examine effects of treatment, collection method, and period (25-39 or 102-107 days post-treatment). Period was removed via backward elimination ($P$ = 0.546). Flea abundance was lower on burrow swabs than on prairie dogs ($P$ = 0.025). The single May treatment was effective for at least ~1 to 3.5 months; fleas were 97% less abundant among prairie dogs and burrows on treated habitat ($P < 0.001$).

These results supplement prior studies, demonstrating the usefulness of 0.005% fipronil grain for prairie dog flea control, here with effective control during periods of peak human visitation at BNP. Prior research (Biggins et al. 2010) suggests the level of flea control observed in our study would have protected prairie dogs, other free-living mammals, and perhaps humans (and pets) against flea bites and potential *Y. pestis* transmission. The treatments should have reduced other potential health complications caused by flea parasitism among prairie dogs (e.g., blood loss, irritation, etc.).

Monitoring off-host flea abundance (i.e., questing fleas) aids in further assessing flea reductions to minimize human risk. Like Poché et al. (2020), we demonstrate the ability of fipronil grain to simultaneously suppress fleas on prairie dogs and in their burrows. At Colony B, we swabbed 193 questing fleas from burrows on non-treated habitat not used for camping. In contrast, we found no questing fleas from burrows on the treated area used by campers, including burrows immediately adjacent to tents actively used by campers.

Historically, plague was sometimes managed by disrupting ecological systems supporting the disease, for instance by poisoning rodents (Jones et al. 2019). Over time, practices shifted toward dust insecticide applications in pre-defined areas. With the latter approach, there is concern with human and non-target exposure to insecticides. Our study demonstrates usefulness of fipronil baits that, in contrast to infusing insecticide dust into prairie dog burrows, target rodent hosts and their fleas, providing a means to reduce exposure for humans and some non-target wildlife.

Education is a key component of One Health (Buttke et al. 2015). At the Colony B campground, interactions with the public were generally positive and educational. During nine mornings of trapping, we were approached by 97 people. We provided a short introduction to plague as a zoonosis and described its impact on humans, pets, wildlife, and ecosystems. We explained the experiment and implications for plague mitigation. Many campers mentioned a fascination with wildlife.

Our experiences with BNP visitors support previous research suggesting One Health approaches to zoonotic disease messaging can increase support for wildlife and intentions to follow public health recommendations (Lu et al. 2016). We interacted with 14 children (perceived to be <18 years-old); they asked many questions, and no negative perceptions were observed. Parents and caretakers emphasized the positive impact this experience had on their children. One adult camper (a teacher) invited us to present to their class. Several children mentioned an interest in becoming wildlife biologists. Educating younger individuals is critical to reducing future negative perceptions of wildlife, given some children will someday join the growing contingent of scientists devoted to One Health objectives.

In addition to the positive One Health impacts noted above, our work likely reduced plague risks for prairie dogs, thereby helping them to serve important ecosystem functions as keystone species (Eads and Biggins 2015). Preservation of prairie dogs also allows the public to observe and appreciate these ecosystem engineers and draws people to learn more about plague as a disease of national concern (https://www.cdc.gov/onehealth/pdfs/us-ohzdp-report-508.pdf).

In summary, the research herein, completed by an interdisciplinary team, provides a successful example of One Health in practice. Human and wildlife health were at the forefront of this effort, which resulted in different approaches than traditional plague mitigation for humans or wildlife alone, and actions were taken to reduce or eliminate unintended consequences of fipronil treatment on humans/pets at one of BNP's busiest campgrounds. This investigation adds to an accumulating number of studies demonstrating the usefulness of fipronil for flea control with rodents. More broadly, this study illustrates the National Park Service's efforts to confront disease risks from a One Health perspective – a critical endeavor that is expected to become increasingly relevant (Buttke et al. 2021).

*Acknowledgments*

Funding and logistical support were provided by the National Park Service, Prairie Wildlife Research, U.S. Geological Survey, U.S. Forest Service (USFS), and U.S. Fish and Wildlife Service (USFWS). We thank D. Biggins, D.

Buttke, P. Dobesh, J. Hughes, M. Schwarz, M.R. Matchett, T. Livieri, many collaborators, and Prairie Wildlife Research, USFWS and USFS for facilitating this research, which was partly designed to assist young scientists in gaining experience with study design, data curation and analysis, and manuscript writing and publication. We thank D. Biggins, two journal reviewers, and the Editor-in-Chief for constructive comments on the manuscript. Field research was completed under USGS Fort Collins Science Center IACUC protocol 2015-17. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

REFERENCES CITED

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 Zoonot. Dis. 10: 17-26.

Buttke, D.E., D.J. Decker, and M.A. Wild. 2015 The role of One Health in wildlife conservation: a challenge and opportunity. J Wildl. Dis. 51: 1-8.

Buttke, D., M. Wild, R. Monello, G. Schuurman, M. Hahn, and K. Jackson. 2021. Managing wildlife disease under climate change. EcoHealth 18: 406-410.

Eads, D.A. 2017. Swabbing prairie dog burrows for fleas that transmit *Yersinia pestis*: influences on efficiency. J. Med. Entomol. 54: 1273-1277.

Eads, D.A. 2022. Data on flea control using fipronil grain bait with black-tailed prairie dogs at Badlands National Park, South Dakota, 2020-2021. U.S. Geological Survey data release. https://doi.org/10.5066/P9WOCEI6.

Eads, D.A. and D.E. Biggins. 2015. Plague bacterium as a transformer species in prairie dogs and the grasslands of western North America. Conserv. Biol. 29: 1086-1093.

Eads, D.A., D.E. Biggins, J. Bowser, K. Broerman, T.M. Livieri, E. Childers, P. Dobesh, and R.L. Griebel. 2019. Evaluation of five pulicides to suppress fleas on black-tailed prairie dogs: encouraging long-term results with systemic 0.005% fipronil. Vector Borne Zoonot. Dis. 19: 400-406.

Eads, D.A., D.E. Biggins, J. Bowser, J.C. McAllister, R.L. Griebel, E. Childers, T.M. Livieri, C. Painter, L.S. Krank, and K. Bly. 2018. Resistance to deltamethrin in prairie dog (*Cynomys ludovicianus*) fleas in the field and in the laboratory. J. Wildl. Dis. 54: 745-754.

Eads, D.A., A.C. Yashin, L.E. Noble, M.C. Vasquez, M.H. Huang, T.M. Livieri, P. Dobesh, E. Childers, and D.E. Biggins. 2020. Managing plague on prairie dog colonies: insecticides as ectoparasiticides. J. Vector Ecol. 45: 82-88.

Eisen, R.J., L.A. Atiku, R.E. Enscore, J.T. Mpanga, S. Acayo, P.S. Mead, T. Apangu, B.M. Yockey, J.N. Borchert, C.B. Beard, and K.L. Gage. 2021. Epidemiology, ecology and prevention of plague in the West Nile Region of Uganda: the value of long-term field studies. Am. J. Trop. Med. Hyg. 105: 18-23.

Jones, S.D., B. Atshabar, B.V. Schmid, M. Zuk, A. Amramina, and N.C. Stenseth. 2019. Living with plague: lessons from the Soviet Union's antiplague system. Proc. Natl. Acad. Sci. 116: 9155-9163.

Lindén, A. and S. Mäntyniemi. 2011. Using the negative binomial distribution to model overdispersion in ecological count data. Ecology 92: 1414-1421.

Lu, H., K.A. McComas, D.E. Buttke, S. Roh, and M.A. Wild. 2016. A One Health message about bats increases intentions to follow public health guidance on bat rabies. PLoS One 11: e0156205.

Poché, D.M., D. Hartman, L. Polyakova, and R.M. Poché. 2017. Efficacy of a fipronil bait in reducing the number of fleas (*Oropsylla* spp.) infesting wild black-tailed prairie dogs. J. Vector Ecol. 42: 171-177.

Poché, D., T. Clarke, B. Tseveenjav, and Z. Torres-Poché. 2020. Evaluating the use of a low dose fipronil bait in reducing black-tailed prairie dog (*Cynomys ludovicianus*) fleas at reduced application rates. Int. J. Parasitol. Parasites Wildl. 13: 292-298.