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Vaccination in the Wild

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STORY AT-A-GLANCE

- Wildlife vaccination is an area of growing interest for scientists, who are working on vaccines to target Lyme disease in deer mice, bovine tuberculosis in white-tailed deer, brucellosis in bison and elk, and white-nose syndrome in bats
- There are significant risks involved, including the potential to worsen herd immunity or increase disease virulence
- Research looking into the effectiveness of an oral sylvatic plague vaccine, delivered in bait, on prairie dogs found those on vaccine plots had worse survival rates than those on placebo plots
- Scientists gave two-thirds of captive endangered black-footed ferrets an experimental COVID-19 shot; the remaining one-third remained unvaccinated in case any long-term adverse effects occurred
- On the heels of the COVID-19 pandemic, researchers proposed using self-disseminating vaccines in the wild, which are vaccinations "capable of autonomously spreading through wild animal reservoirs"

Black-footed ferrets are among the most endangered species in the world. Found only in North America's central grasslands, these carnivorous rodents are largely dependent on prairie dogs for food.

But with prairie dogs decimated by sylvatic plague and, according to a report from the U.S. Department of Agriculture Animal and Plant Health Inspection Service, "an

agricultural industry with little tolerance for burrowing and grazing rodents," their numbers reached a low point of just 18 individuals remaining in the wild.[1]

"With heroic efforts by federal, state, and private scientists, immediate extinction was forestalled, and a comeback effort mounted," the report explains. Vaccinations are key among these efforts, but one of "last resort" that's also not without risk.

Prairie Wildlife Research biologist Travis Livieri, who worked on the USDA report, told The Atlantic, "I'm like an alien-abduction machine."[2] His goal is to catch each of the estimated 200 black-footed ferrets living in South Dakota's Conata Basin and give them a plague vaccine.[3] But will it be enough to save the species — and could there be unintended consequences?

Vaccines 'Almost a Sign of Desperation'

Tonie Rocke, a research scientist with the U.S. Geological Survey, told The Atlantic there are only two reasons that justify vaccination in the wild — "to prevent spillover to domestics and humans of a zoonotic disease, and for conservation purposes." Still, Jean Tsao, a disease ecologist with Michigan State University, said, "The fact that we're looking at vaccines now is almost a sign of desperation."[4]

As it stands, there are only about 350 black-footed ferrets left in the wild. They're just one of the casualties as grasslands have been largely uprooted to make way for industrial agriculture. Chamois Andersen, senior representative, Rockies and Plains Program, with Defenders of Wildlife, explained:[5]

> *"North America's western grasslands once held an abundance of wildlife, from thundering bison herds to vast prairie dog colonies and untold numbers of grassland birds. But today grasslands are the most threatened, least protected habitat on Earth. With black-footed ferrets teetering on the brink of extinction, healthy grassland ecosystems are essential to their survival."*

In addition to the habitat concerns, sylvatic plague killed two-thirds of prairie dog and ferret populations in the area in 2008. A flea-borne disease, efforts began — and

continue — to target plague in fleas in order to boost prairie dog populations and, subsequently, allow black-footed ferrets to flourish. According to Andersen:[6]

> *"At Conata Basin, efforts to prevent or lessen the effects of plague are paying off. But each summer we have to ensure prairie dogs and ferrets stay protected. This involves preventing plague by applying an insecticide which kills the fleas that spread the plague throughout the prairie dog colonies.*
>
> *This also involves trapping, vaccinating, and releasing ferrets during the annual population survey at Conata Basin. And finally, experiments in vaccinating prairie dogs using a pellet bait they ingest also continue."*

Annual Flea Treatments for Wildlife?

Grain bait laced with fipronil, a broad-spectrum insecticide commonly used in flea products used on domestic dogs, is used to control fleas in wild prairie dogs. When tested on black-tailed prairie dogs (BTPD) and black-footed ferrets (BFF) in South Dakota, fleas were reduced — but began to rebound about 240 days after treatment.[7]

As a result, the researchers said, "When feasible, the combination of insecticide treatments, such as fipronil baits, and BFF vaccination against plague provide a "two-pronged" protection approach for these endangered carnivores."[8]

However, fipronil is already widespread in the environment, where it's poisoning waterways and their inhabitants. The chemical has been found to "degrade stream communities" even at low concentrations.[9] And a U.S. Geological Survey study found fipronil reduced species diversity and was particularly harmful for aquatic insects.

When introduced to a stream mesocosm ecosystem, the chemical altered the food web and triggered a tropic cascade. Beyond Pesticides reported:[10]

> *"A trophic cascade occurs when a disruption, in this case a pesticide, significantly reduces, changes the behavior of, or destroys certain populations of plants and animals, causing effects that ripple up and down the food chain.*

> *In this instance, fipronil harmed populations of insects known as scrapers (sometimes known as grazers) which include snails other aquatic insects that feed on algae.*
>
> *This results in a bloom in algae populations. Although fipronil is not a fertilizer, it nonetheless has the potential to indirectly cause harmful algae blooms in U.S. streams and waterways."*

So introducing more of this chemical into the environment, while effective at controlling fleas, has off-target consequences that must be factored into the conservation efforts.

Plague Vaccine Doesn't Provide 'Adequate' Protection

Research looking into the effectiveness of an oral sylvatic plague vaccine, delivered in bait, on prairie dogs wasn't reassuring. In an assessment spanning from 2013 to 2017 on the Charles M. Russell National Wildlife Refuge (CMR) in northcentral Montana, scientists followed prairie dogs on vaccine plots and placebo plots. Those on the vaccine plots were worse off than those on the placebo areas.

According to the study, "Overall, survival averaged 0.05 lower on vaccine plots than on paired placebo plots." This occurred despite an estimated 89% of prairie dogs consuming at least one vaccine-laced bait and 40% having likely consumed the vaccines in multiple years prior. The team noted:[11]

> *"Such low survival rates on vaccine plots are especially troubling given 3 consecutive years of SPV [sylvatic plague vaccine] treatment before plague detection and where confirmed SPV bait consumption histories indicated 89% of sampled BTPD had consumed at least one bait, and 40% had likely been boosted having consumed bait in multiple years."*

With each bait costing 54 cents, not including costs for equipment and labor to deliver the baits, it doesn't appear to be a cost-effective solution, particularly considering it didn't improve survival in the prairie dogs. The study concluded:[12]

> *"For SPV to be considered a useful BFF conservation tool, treatment should result in substantially greater PD survival than no treatment … When plague was detected on our study plots, BTPD survival was low, often <10%, on paired vaccine and placebo plots alike.*
>
> *Such high BTPD mortality would jeopardize BFF population persistence. Similarly, low PD survival on vaccine plots was observed in Colorado and Wyoming, indicating this result was not unique to our Montana study site. Plague may continue circulating as fleas are not controlled with SPV treatments, leaving BFF susceptible to plague."*

The team cited "vaccine delivery constraints" as a key reason for the vaccine's failure, which is perhaps why researchers are now trying a more targeted approach at vaccination. The sylvatic plague vaccine being given to the black-footed ferrets is an injectable variety.[13] In addition to wild black-footed ferrets receiving the plague vaccine, kits released for reintroduction also receive the shot before they're allowed to mingle with the group.[14]

Endangered Ferrets Given Experimental COVID Shot

The U.S. Fish and Wildlife Service's (USFWS) National Black-footed Ferret Conservation Center in Colorado is home to most captive-bred black-footed ferrets. After scientists learned that ferrets' close cousins like European mink and domestic ferrets could be infected with SARS-CoV-2, they decided to give them experimental COVID-19 shots.[15]

No black-footed ferrets had contracted COVID-19 — and the team wasn't even sure they could be infected — but that didn't stop the researchers from giving them COVID-19 shots anyway. In 2021, the USFWS authorized the shots in a small group of black-footed ferrets, which produced antibodies against SARS-CoV-2.[16]

The team then moved forward, giving two-thirds of the black-footed ferrets at the Center a COVID-19 shot. According to The Wildlife Society, "While no adverse effects related to

the ferret inoculation have been discovered, the researchers still left a third unvaccinated in case any long-term impacts cropped up."

Meanwhile, as in humans, the antibodies the ferrets developed showed signs that they were decreasing over time, leading researchers to suggested they might need booster doses of the shot.[17]

More Wildlife Vaccines Are in the Works

Already, rabies vaccines packaged in fishmeal have been dropped over large areas of Tennessee to eradicate the disease in raccoons.[18] Little is known, however, about what happens if pets or other wildlife consume the vaccine packets — and this is only the beginning.

Wildlife vaccination is an area of growing interest for scientists, who are working on vaccines to target Lyme disease in deer mice, bovine tuberculosis in white-tailed deer, brucellosis in bison and elk, and white-nose syndrome in bats. Vaccination programs to target canine distemper in tigers, lions, African wild dogs and Ethiopian wolves have also been developed.[19]

But there are significant risks involved, including the potential to worsen herd immunity or increase disease virulence. Writing in Trends in Parasitology, researchers with Emory University in Atlanta noted:[20]

> *"Vaccines rarely provide perfect immunity. While some protection may seem better than none, imperfect vaccination can present epidemiological, ecological, and evolutionary challenges.*
>
> *While anti-infection and antitransmission vaccines reduce parasite transmission, antidisease vaccines may undermine herd immunity, select for increased virulence, or promote spillover. These imperfections interact with ecological and logistical constraints that are magnified in wildlife, such as poor control and substantial trait variation within and among species."*

Self-Disseminating Vaccines — What Could Go Wrong?

On the heels of the COVID-19 pandemic, researchers also proposed using self-disseminating vaccines in the wild, which are vaccinations "capable of autonomously spreading through wild animal reservoirs."[21] What could go wrong with unleashing a self-spreading vaccine into the environment? There's no way to stop it — and no going back one it's done.

As the Trends in Parasitology team noted, the sustained replication and transmission "creates substantial opportunities for evolution." They used the example of the live polio vaccine, which evolved and now circulates in the wild, spreading disease. They also explained that self-disseminating vaccines could end up in unintended hosts or increase virulence:[22]

> *"[U]sing a novel vector that is not circulating in the animal reservoir has the advantage of avoiding prevailing immunity but runs the risk of unknown evolution and virulence upon release. Further, there is at least some possibility that the immunogenic insert could be co-opted by the viral vector to expand its ecological niche by allowing access to new tissues or even hosts."*

Given the extreme risks, the team suggested a series of steps to reduce unanticipated consequences, but then stated, "It will often be impractical to adhere to all of these recommendations, and caution may give way to expedience if the consequences of pathogen spillover are great."[23] In other words, the precautionary principle doesn't seem to matter.

They even stated, "the logical next step is to begin developing and testing transmissible vaccines."[24] While saving endangered species and stopping the spread of disease among wildlife is a noble cause, we must ensure that the "cure" isn't worse than the disease — or capable of setting off another environmental catastrophe with no known solution.

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