REHABILITATION OF A SPECIES: THE BLACK-FOOTED FERRET (*Mustela nigripes*)

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INTRODUCTION

Black-footed ferrets (*Mustela nigripes*) are an endangered carnivore endemic to North America. This small nocturnal member of the weasel family is totally dependent on the prairie dog (*Cynomys* spp.) ecosystem for survival. The ferret lives in prairie dog burrows and relies on prairie dogs for 90 percent of its diet (3,21). Poisoning of prairie dogs was largely responsible for the 98 percent reduction in geographic distribution of prairie dogs (14); concurrently, black-footed ferret numbers plummeted. Recently, only a single known population of black-footed ferrets remained. In 1985 that population, located near Meeteetse Wyoming, succumbed to an outbreak of canine distemper, and the few remaining ferrets were taken into captivity in an attempt to save the species through captive propagation (22).

Although no wild populations of black-footed ferrets are known to exist, the captive population now numbers about 180 (before the 1991 breeding season). The first release of captive-born ferrets is scheduled for the fall of 1991. But many captive-raised animals have had poor success after reintroduction into their natural habitat. The effects of captivity may alter behavioral and physiological traits that are critical for survival (6). The timing of first expression of a behavioral trait and the number of times it is expressed throughout development can affect the performance of that behavioral trait as an adult (7). So the captive environment can be very important to the survival of released animals.

For the past 2 years the authors have been studying methods of pre-release preparation and release techniques that would facilitate survival of captive-raised black-footed ferrets in the wild. Because of the small number of black-footed ferrets, a congeneric surrogate, the Siberian ferret (*Mustela eversmanni*), was used for this reintroduction research. The Siberian ferret is very similar morphologically and ecologically to the black-footed ferret (10). This research has addressed foraging efficiency and predator avoidance responses in captive-raised Siberian ferrets. These results are discussed with application to other species.

CAPTIVE BREEDING AND REINTRODUCTION

The wild black-footed ferret population is an excellent example of the vulnerability of small populations. By 1981 only one known wild population of black-footed ferrets remained (west of Meeteetse, WY), and it was decimated by canine distemper in 1985 (22). The few remaining black-footed ferrets were taken into captivity in an effort to save the species through captive propagation.

Captive breeding, headed by the Wyoming Game and Fish Department in cooperation with the U.S. Fish and Wildlife Service and the International Union for the Conservation of Nature's Captive Breeding Specialist Group, has been successful. There are now 183 black-footed ferrets, whereas in the winter of 1985–1986 there were probably as few as 10 or 11 (six in captivity and four or five in the wild). But breeding animals in captivity is only part of a successful recovery program. The captive-raised animals must next be returned to prairie dog ecosystems on the western prairies.

The effects of captivity on natural behavior and physiology are not well defined, and there is much variability from species to species (12). The poor success of many captive-raised species following reintroduction has led to a critical evaluation of the captive environment. Derrickson and Snyder (6) speculated that selective pressures are not absent, but simply redirected to alter behavioral repertoires important to survival in the wild. In addition, relaxed selection pressures may cause erosion of behavioral traits that are genetically expensive to maintain or that require some level of cultural transmission to be passed from generation to generation.

The development of any complex behavioral pattern is the result of extensive interaction between genetics and the animal's experience (17). Instinctive behaviors may have to be expressed at the appropriate time during the animal's development and may require repeated cues throughout development if those behaviors are to be performed efficiently as adults (7). Early experience can alter brain size and other cerebral measures that potentially affect behavior later in life (8,20). Presenting captive animals with stimuli resembling those prevalent in their natural environment may help some individuals retain adaptive traits and, therefore, increase post-release survival. A captive environment that is closer to nature may prevent released animals from learning wild behaviors in inappropriate ways or at incorrect periods of development.

Because wild weasel populations can be controlled by predation (18), predator avoidance traits may be particularly important to the black-footed ferret. In 1989 the U.S. Fish and Wildlife Service National Ecology Research Center and the Conservation and Research Center of the National Zoological Park used predators mounted in lifelike positions to test predator avoidance responses in captive-raised Siberian ferrets aged 2, 3, and 4 months (15). The predators were a badger (*Taxidae taxus*) mounted around a remote-control toy truck frame and a great horned owl (*Bubo virginianus*) suspended by a string so that it could be swooped overhead.

At 2 months of age naive Siberian ferrets showed no innate escape response nor did they learn from an aversive contact (supplied by shooting the ferrets with rubber bands) with the predator models (15). At 3 months of age naive Siberian ferrets showed increased alertness and the ability to improve an escape response after a single unpleasant contact with the predator models. At 4 months of age, naive Siberian ferrets showed increased alertness when confronted with the badger and an escape response significantly faster than the control when confronted with the owl. Four-month-old Siberian ferrets could improve their escape responses after a single aversive experience with the predator models (15).

Siberian ferrets and a number of other mustelids are capable of killing prey on first encounter in captivity, but locating prey in natural situations may be a separate behavior from killing. For example, two hand-raised fishers (*Martes pennanti*) could kill porcupines (*Erithrizon* *dorsatum*) on first opportunity in captivity but starved to death after release in the wild, because they apparently did not know how to locate prey (11). Black-footed ferrets must locate and kill prairie dogs, a formidable prey item, in order to survive. Ferrets may also have to adjust their prey location techniques when searching for hibernating white-tailed prairie dogs (*Cynomys leucurus*) during winter, when higher rates of ferret digging activity have been reported (5,19).

The ability of young Siberian ferrets to locate food was tested in an enclosed, 200-m^2 prairie dog arena. Captive Siberian ferrets could innately locate food in a burrow, and they did so progressively faster as they aged (16).

Although the Siberian ferrets became more efficient in locating prey, they still spent a great deal of time in casual surface activity unrelated toward burrows, both in the captive experiments and after release into the wild (2,16). This casual surface movement increased their exposure to predators. More than just individual behaviors must be considered, because the way a behavioral trait is expressed depends on the simultaneous use of other behaviors necessary for survival and reproduction. For example, many animals (including carnivores) alter their foraging styles according to the density of potential predators (4). Training or preparing one behavior at a time may offer only simplistic solutions to the complex problems a captive-raised animal will face after release in the wild.

Experiment 1. To further refine pre-release conditioning, responses of eight captive-born Siberian ferrets raised from 3.5 months of age in the enclosed prairie dog town were compared with responses of eight pen-raised Siberian ferrets when both groups were introduced to a new environment. The 200-m^2 prairie dog town included live prairie dogs, prairie dog burrows, and predation stimuli (in the form of a live domestic dog). The pen-raised Siberian ferrets lived in 1.5- x 1.5-m cages containing a nest box and a concrete block. Pen-raised animals lacked access to burrows and had no access to live prey or predation stimuli.

At 4.5 months of age, all animals were individually introduced to a neutral, 4- x 4-m dirt-filled arena at midday for 30 minutes. An escape nest box was located with the entrance flush to the surface of the soil to simulate a prairie dog burrow. This pen presented captive-raised Siberian ferrets with a new environment to mimic the circumstances after reintroduction.

Mean time spent in the escape box was significantly longer for

Siberian ferrets raised from 3.5 months of age in the prairie dog town (730 seconds, $SD = 359$) than for the cage-raised ferrets (286 seconds, $SD = 126$; $t = 3.422$, $df = 7$, $P = 0.011$). Siberian ferrets raised in the seminatural prairie dog town typically investigated the new arena, then settled in the nest box and had to be removed from the box after the 30-minute test. In contrast, pen-raised animals typically investigated the arena, entered and exited the box at short intervals, but never settled in the underground nest box.

Experiment 2. Experiment 1 compared animals that had access to both prairie dog burrows and predation stimuli to animals that had exposure to neither. A second experiment compared responses of Siberian ferrets with and without exposure to a live domestic dog using only cage-raised animals. Both groups of adult Siberian ferrets were raised in cages with a single nest box available. Encounters occurred in the 4- x 4-m dirt-floor arena described in experiment 1. One group of 15 Siberian ferrets was harassed by a live domestic dog in the arena, and a second group of 16 animals had no previous experience with the dog.

One week after exposure to the dog, individuals from both groups were placed in the 4- x 4-m arena with no dog present for 20 minutes. Two weeks after exposure to the dog, individuals from both groups were again returned to the arena. This time a door at one side of the arena was opened to allow the Siberian ferrets a quick view of the restrained domestic dog.

One week post-harassment, Siberian ferrets from both groups (domestic dog experienced and dog inexperienced) spent similar periods of time in the underground nest box when the dog was not present. When ferrets from each group were exposed to the dog in the arena 2 weeks post-treatment, more dog-experienced ferrets entered the burrow (10 out of 15) than did control animals (3 out of 16). Dog-experienced animals that entered the burrow spent more mean time ($t = 2.00$, $df = 11$, $P = 0.075$) below ground (123.8 seconds, $SD = 171.4$) than control animals (15.3 seconds, $SD = 6.2$).

These results suggest that Siberian ferrets can remember a threatening experience with a predator for at least 2 weeks and make an appropriate escape response (enter a burrow). The data from the first part of experiment 2 (exposure to the arena with no domestic dog present 1 week post-harassment) indicate that kits from experiment 1 spent more time below ground because they were raised from 3 months of age with prairie dog burrows available, not because of prior experience with a predator. Ferrets from experiment 2, however, did remain underground longer when a predator was present. Increased time below ground will decrease the probability of random above-ground encounters between ferrets and predators, and that behavior is disproportionately more valuable when a predator is known to be in the vicinity of the ferret. When an animal is introduced to a new environment a certain amount of investigative behavior can be expected. But wild-raised black-footed ferrets normally spend a large proportion of their time underground in prairie dog burrows (1). This behavior is presumably adaptive for avoiding predation, and predation will likely be a major threat to successful black-footed ferret reintroduction.

Experiment 3. The effect of killing experience on killing efficiency was studied in experiment 3. Captive-born, cage-raised Siberian ferrets ($n = 17$) were presented with live white lab mice for seven consecutive days. One week later, those 17 ferrets and 17 captive-born, cage-raised Siberian ferrets with no killing experience were individually presented with a live lab mouse in a neutral arena. Efficiency in killing the mouse was rated subjectively (considering equally time to attack, ferocity of attack, and efficiency of dispatch) from 1 to 15 (15 being the best) by four observers. Those four scores for each individual Siberian ferret were averaged. The observers did not know whether the individuals were in the treatment or control group. A Chi-square goodness of fit test showed no significant differences between observers.

Using a two-tailed Mann-Whitney ranks test, scores of Siberian ferrets with killing experience were significantly higher than the control ($U = 211.5$, $P \leq 0.05$). It appeared from these experiments that rearing captive-born ferrets in an enriched pre-release environment that provides burrow systems, live prey, and a stimulus simulating predator encounters may help sharpen responses necessary for survival after release. The benefits of this enriched pre-release environment may be further heightened if mothers have had previous experience hunting and avoiding predators.

APPLICATIONS TO WILDLIFE REHABILITATION

There are gradations in an animal's ability to survive when rehabilitated and released into the wild. Most success likely comes from releasing wild-raised, injured animals that have been rehabilitated within a short time of their capture. Survival of captive-raised animals released into the wild has been less successful (9). The pre-release studies with captive-raised Siberian ferrets indicate that animals raised in seminatural environments may perform critical behavioral traits more efficiently after release. This, in turn, should lead to higher survival.

Indeed, during a recent experiment to release captive-raised Siberian ferrets, the authors saw best success from animals raised in an enclosed prairie dog arena. Those animals had to hunt, kill, and occasionally escape predation from a live domestic dog. They were subjected to normal weather conditions as well as parasites such as fleas and ticks. The red wolf project uses a similar strategy by raising wolves on an island before their release (W. Parker, oral communication). The benefits of various pre-release conditioning programs preceding reintroduction of captive-raised animals was discussed by Kleiman (12).

Simulating the real world does not mean providing a larger, more pleasant cage. In nature an animal can be cold and wet. It can exist for long periods without a meal and suffer from parasites and disease. And there is the constant threat of being preyed upon. There may even be fatal contact during social conflict. These are situations that a wild animal must face and overcome on a daily basis if it is to survive. If an environment that will preserve adaptive characteristics in a captive population is to be provided, that environment must subject the captive population to the same stresses and risks that honed those survival skills in the wild (13). Human interaction with potential release animals must be limited as much as possible (experimental hand-raised ferrets were unable to kill and showed little ability to avoid predators).

This may create a dilemma for captive handlers who see intervention as a way to protect individuals. It also can be difficult for handlers when a favorite animal is injured. Some people may have difficulty understanding that treating animals as pets will impair adaptive characteristics necessary for survival in the wild. To alleviate this dilemma the golden lion tamarin (*Leontopithecus rosalia*) project sets standard policies on when to intervene, discourages the use of animal names, and does not allow workers to interact with or "talk at" wild animals (B. Beck, oral communication).

Finally, for conservation efforts (whether rehabilitated individuals or reintroduction of a species) to succeed, there is a critical need to closely monitor releases. Monitoring will identify mortalities, distribution of released animals, and life history attributes that will assist in guiding future releases. Without such knowledge it would be very difficult to increase survival in subsequent reintroduction attempts. In most cases, successful monitoring can best be accomplished using radio telemetry. Many wildlife rehabilitation centers do not have a large enough staff to monitor animals after release, but much of this work could be done by graduate students. This type of study could both refine handling techniques for individual animals, as well as provide surrogate studies for techniques applicable to conservation of rare and endangered species.

LITERATURE CITED

1. Biggins, D.E., M.H. Schroeder, S.C. Forrest, and L. Richardson. 1985. Movements and habitat relationships of radio-tagged black-footed ferrets. Pp. 11.1–11.17 *in* Proceedings of the Black-footed Ferret Workshop, September 18–19, 1984. (S.H. Anderson and D.B. Inkley eds.). Wyoming Game and Fish Department, Cheyenne, WY.
2. Biggins, D.E., L.R. Hanebury, B.J. Miller, and R.A. Powell. 1990. Release of Siberian polecats on a prairie dog colony. 70th Annual Meeting of the American Society of Mammalogists, June 9–13, 1990, Frosburg, MD (abstract).
3. Campbell, T.M., T.W. Clark, L. Richardson, S.C. Forrest, and B. Houston. 1987. Food habits of Wyoming black-footed ferrets. American Midland Naturalist, 117:208–210.
4. Caro, T. 1989. Missing links in predator and antipredator behavior. Trends in Ecology and Evolution, 4:333–334.
5. Clark, T.W., L. Richardson, D. Casey, T.M. Campbell, and S.C. Forrest. 1984. Seasonality of black-footed ferret diggings and prairie dog burrow plugging. Journal of Wildlife Management, 48:1441–1444.
6. Derrickson, S.R. and N.F.R. Snyder. In press. Potentials and limits of captive breeding in parrot conservation. *In* New World Parrots in Crisis: Solutions from Conservation Biology. (S.R. Beissinger and N.F.R. Snyder, eds.). Smithsonian Institution Press, Washington, DC.
7. Gossow, H. 1970. Vergleichende verhaltensstudien an Marderartigen I. uber Lautausserungen und zum Beuteurhalten. Zeitschrift fur Tierpsychologie, 27:405–480.
8. Greenough, W.T. and J.M. Juraska. 1979. Experience induced changes in brain fine structure: Their behavioral implications. Pp. 263–294 *in* Development and Evolution of Brain Size: Behavioral Implications. (M.E. Hahn, C. Jensen, and B.C. Dudek, eds.). New York Academic Press, New York, NY.
9. Griffith, B., J.M. Scott, J.W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science, 245:477–480.
10. Hoffmann, R.S. and D.L. Pattie. 1968. A Guide to Montana Mammals. University of Montana, Missoula, MT.
11. Kelly, G.M. 1977. Fisher (*Martes pennanti*) Biology in the White Mountain National Forest and Adjacent Areas. Ph.D. dissertation. University of Massachusetts, Amherst, MA.

12. Kleiman, D.G. 1989. Reintroduction of captive mammals for conservation. Bioscience, 39:152–161.
13. Kleiman, D.G., B.B. Beck, J.M. Dietz, and L.A. Dietz. In press. Costs of a reintroduction and criteria for success: accounting and accountability in the golden lion tamarin conservation program. *In* Beyond Captive Breeding: Reintroducing Species to the Wild. (J.H.W. Gipps, ed.). Oxford University Press, Oxford, England.
14. Marsh, R.E. 1984. Ground squirrels, prairie dogs and marmots as pests on rangeland. Pp. 195–208 *in* Proceedings of the Conference for Organization and Practice of Vertebrate Pest Control, August 30–September 3, 1982, Hampshire, England. ICI Plant Protection Division, Fernherst, England.
15. Miller, B., D. Biggins, C. Wemmer, R. Powell, L. Calvo, L. Hanebury, and T. Wharton. 1991. Development of survival skills in captive-raised Siberian ferrets (*Mustela eversmanni*) II. Predator avoidance. Journal of Ethology, 8:95–104.
16. Miller, B., D. Biggins, C. Wemmer, R. Powell, L. Hanebury, D. Horn, and A. Vargas. 1991. Development of survival skills in captive-raised Siberian ferrets (*Mustela eversmanni*) I. Locating prey. Journal of Ethology, 8:89–94.
17. Polsky, R.H. 1975. Developmental factors in mammalian predation. Behavioral Biology, 15:353–382.
18. Powell, R.A. 1973. A model for raptor predation on weasels. Journal of Mammalogy, 54:259–263.
19. Richardson, L., T.W. Clark, S.C. Forrest, and T.M. Campbell. 1987. Winter ecology of black-footed ferrets (*Mustela nigripes*) at Meeteetse Wyoming. American Midland Naturalist, 117:225–239.
20. Rosenzweigh, M.R. 1979. Responsiveness of brain size to individual experience: behavioral and evolutionary implications. Pp. 263–294 *in* Development and Evolution of Brain Size: Behavioral Implications. (M.E. Hahn, C. Jensen, and B.C. Dudek, eds.). New York Academic Press, New York, NY.
21. Sheets, R.G., R.L. Linder, and R.B. Dahlgren 1972. Food habits of two litters of black-footed ferrets in South Dakota. American Midland Naturalist, 87:249–251.
22. Williams, E.S., E.T. Thorne, M.J.G. Appel, and D.W. Belitsky. 1988. Canine distemper in black-footed ferrets (*Mustela nigripes*) in Wyoming. Journal of Wildlife Diseases, 24:385–398.

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