Many species of vertebrates harbor diverse parasite faunas. Often these species of parasites are host-specific, and some spend their entire life cycle on the host. As a result, when the population size of a host is reduced, the population sizes of these host-specific parasites also may be reduced. The decline in the parasite population may be exacerbated if contact between hosts is rare but necessary for transmission between hosts. A decrease in the population size of a host may result in a decrease in the contact rates of individual hosts due, for example, to population social structure, nonrandom dispersal patterns, or geographical subdivision in the population. Populations of parasites on the few remaining hosts may go extinct due to normal stochastic fluctuations in population size before contact between hosts allows migration and recovery.

The population dynamics of species of parasites raise philosophical and applied problems for practitioners of conservation biology—problems that have received scant attention. Large, charismatic, or economically important species such as pandas and salmonids receive far more attention and recovery resources than do small, less renowned species such as invertebrates. Parasitic species are currently the victims of this unfortunate circumstance, and interest in the conservation biology of parasites is rare. Whether parasitic species should be the losers among current conservation priorities is a topic that deserves far more discussion.

The Black-Footed Ferret

To illustrate the intricacies and practical difficulties of these issues, we discuss efforts made to save the endangered black-footed ferret (*Mustela nigripes*) and conflicts these efforts may have created for obligate parasites of the species. Our goal is not to criticize these efforts but to focus on issues that could alter how future remediation plans are undertaken. *Mustela nigripes* is a small mustelid that is highly dependent on prairie dog (*Cynomys* spp.) communities. Ferret numbers declined precipitously throughout the 1990s because of prairie dog eradication programs, and the species was believed extinct until a single population was discovered in 1981 (Clark 1989). Between 1982 and 1985, this population was studied intensely, which sometimes involved removing ectoparasites and dusting individuals with carbaryl powder to reduce ectoparasite infestations (Thorne et al. 1985; Cole 1989). Prairie dog (*C. leucurus*) colonies were also dusted with insecticide to reduce fleas populations, which carried sylvatic plague (*Yersinia pestis*; Thorne & Williams 1988). In 1986 a combination of plague in the prairie dog prey base and canine distemper among the ferrets led to capture of the remaining black-footed ferrets and formation of a captive colony derived from 18 individuals. The captive population is now over 300 individuals, and reintroductions have occurred in Wyoming, Montana, Arizona, and South Dakota.

Intensive efforts were made to minimize the risk of disease transmission among captive black-footed ferrets. Wild-trapped animals were vaccinated against canine distemper and kept in quarantine before being moved to the breeding facilities (Thorne & Williams 1988; Cole 1989). Although no host-specific parasites of the black-footed ferret have been positively confirmed, a checklist of North American biting lice (Emerson 1964) lists *Neotrichodectes minutas*, a louse typically found on weasels, as occurring on black-footed ferrets and suggests that the *Neotrichodectes* found on *M. nigripes* may be a distinct species. It is not known whether *Neotrichodectes* existed among the rediscovered Wyoming ferrets, and unfortunately we will probably never know
whether the Neotrichobodectes was unique to *M. nigripes*, for if it did exist it is likely now extinct. Captive *M. nigripes* are closely monitored for parasites and pathogens. As of July 1997, *Neotrichobodectes* did not exist in the captive populations, and no other host-specific species of ectoparasite have been observed. Thus, it is likely that any ectoparasite that was host-specific to *M. nigripes* is extinct.

A unique endoparasitic protozoan, probably *Eimeria* sp., was also present, although rare, in free-ranging and captive *M. nigripes* shortly after they were brought into captivity, but it has not been observed in the principal captive population since 1991 (Williams et al. 1992; Jolley et al. 1994; E. T. Thorne, personal communication). The captive population, however, harbors two species of *Eimeria* that are morphologically compatible with but that may be biological variants of parasites known in domestic ferrets (*M. putorius furo*) and mink (*M. vison*). When the *M. nigripes* population was taken into captivity, a conscious decision was made not to attempt eradication of the *Eimeria* population from the host population, despite the fact that this parasite can occasionally kill ferrets. This decision was made so that captive individuals and animals destined for release would be exposed to endogenous parasites and develop appropriate immune responses prior to possible exposure to similar parasites in the wild (Williams et al. 1992; E. T. Thorne, personal communication).

As illustrated by the ferret recovery program, the obligatory host-parasite relationship presents management paradoxes when the host is in danger of extinction. For example, without an extensive survey it is difficult to determine what parasites are host-specific to a species. This difficulty is increased for rare or protected species because individual hosts may be inaccessible. Also, the minimum host population size necessary to maintain a population of parasites is unlikely to be known, and in fact might be greater than that required to draw the attention of conservation biologists. In other words, a species of host-specific parasite may go extinct before biologists consider a host population to be in jeopardy. Thus, we do not know if *M. nigripes* ever had host-specific parasites (with the possible exception of the *Neotrichobodectes* and *Eimeria* spp.), if the parasites were lost prior to *M. nigripes* receiving intensive recovery efforts, or if the recovery efforts themselves led to the demise of any species of parasite. When the few remaining hosts are closely managed, especially in captivity, techniques oriented toward increasing host numbers could exacerbate the situation and actively drive the parasite to extinction. Managing for the benefit of the parasite may require high contact rates among hosts, which might increase transmission of generalist parasites or pathogens to the detriment of the host. The *M. nigripes* recovery program has been hampered by outbreaks of canine distemper (Williams et al. 1988), and for undetermined reasons *Cryptosporidium* continues to be a problem in individual animals. Both pathogens are probably exotic to *M. nigripes*.

Why Conserve Parasitic Species?

It is difficult to foresee overcoming monetary obstacles and negative public perceptions to initiate a program to conserve a species of parasite. Nonetheless, many of the arguments advanced for conserving biodiversity or saving individual species also apply to species of parasites. For example, the medicinal or research uses of parasitic species may directly serve humans (Elliott & Tullett 1984; Joklik et al. 1993). In addition, parasite community ecology suggests that the loss of one parasite species can alter competitive interactions among remaining parasite species (Sousa 1990; Fernandez & Esch 1991), possibly to the detriment of the host. This implies an economic or utilitarian argument for the preservation of parasites: maintaining populations of host-specific parasites may be important for the continued health or survival of the host population that we desire to save. Ethical, moral, and aesthetic arguments used to justify conserving individual taxa also support conserving viable, natural populations of parasites. Measures such as intrinsic value apply equally to the parasite and the host (Callcott 1986; Norton 1988). Thus, utilitarian and nonutilitarian decisions not to save parasite species are poorly justified.

The issues we raise are not entirely new. Stork and Lyal (1993) noted that the extinction of the Passenger Pigeon (*Ectopistes migratorius*) also resulted in the extinction of two species of host-specific lice. Windsor (1995) lamented the negative image of parasites and the lack of attention given to parasite conservation biology. Unfortunately, it may be naïve to believe that those unfamiliar with justifications for conserving individual species and biodiversity will support a program for conserving parasites. In the United States, perceptions of invertebrates are negative, and most of the general public disapprove of expenditures to protect endangered invertebrates (Kellert 1993). Also, there is a fine line between attempting to save seemingly benign parasites of nonhumans and their more virulent human counterparts. In a charged political climate, attempts to conserve unique species of parasites could result in a backlash against attempts to conserve hosts.

The issue of how to deal with threatened parasite species will only increase in importance as awareness grows among conservation biologists and parasitologists and as populations of more potential host species decline. Several steps may be taken to save these noncharismatic species without damaging efforts to maintain or restore host populations: (1) Survey for host-specific parasites prior to enacting single-species conservation programs. Many species may have no host-specific parasites, in
which case the controversial management questions are not applicable. (2) Search for alternative hosts to maintain the parasite population for potential reintroduction when the host population is restored. (3) Establish a program to conserve the host-parasite interaction rather than or in addition to the single-species programs. (4) Place greater emphasis on community preservation rather than single-species remediation programs. This last possibility may be more sociopolitically acceptable than a program with the specific goal of increasing the numbers of a parasite, whether in concert with its host or as a single-species recovery program.

Literature Cited


