

INVASIVE STRAY AND FERAL DOGS LIMIT FOSA (*CRYPTOPROCTA FEROX*) POPULATIONS IN
ANKARAFANTSIKA NATIONAL PARK, MADAGASCAR

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ABSTRACT

The fosa (*Cryptoprocta ferox*) is a medium sized carnivore of the family Eupleridae which is endemic to the island of Madagascar. Recent publications have shown that the fosa is under significant pressure from deforestation and fragmentation, leading to its classification as Threatened under the Endangered Species Act. A trap study was conducted from 1999 to 2008 in Ankarafantsika National Park, Madagascar, to ascertain the health of a population and measure additional threats to its survival. Feral dogs (*Canis lupus familiaris*) appeared in the park in 2004 and a comparison of trap rates of the two species shows an inverse relationship between the presence of dogs and the presence of fosa. In this paper I discuss reasons for this relationship, the effect of the continued presence of dogs, and implications for the management of the park.

INTRODUCTION

The progressive deforestation of Madagascar has been cited as the primary reason for the current status of the fosa (Hawkins, 2005) but I present and investigate an additional, overlooked cause. Stray and feral dogs are a substantial threat in areas inhabited by wildlife already vulnerable, owing to habitat disturbance. On islands in particular, the effect of these invaders is dramatic (Van't Woudt, 1990). Schoener (1983), in a review of studies on competition, concluded that competition over resources, especially in regard to rare species, can be a powerful force in species interactions though it may be small and difficult to detect.

The management of forests is of primary concern to conservationists in Madagascar, especially considering the effects of deforestation and habitat fragmentation on the wildlife contained therein. The fosa is a member of the endemic family Eupleridae, existing only in these tropical forests. It is the largest terrestrial carnivore on the island, second only to the Nile Crocodile. Despite this, the mean

body mass of males is only approximately 7.5 kg (Hawkins and Racey, 2005). Here, I examine the interspecific competition between the fosa (*Cryptoprocta ferox*), an apex carnivore, and invasive domestic dogs (*Canis lupus familiaris*) in a dry deciduous tropical forest in Madagascar.

With no natural predators, the fosa has free reign of the forests and takes advantage of this by preying upon nearly every creature in its habitat. Dollar et al. (2006) identified the remains of at least twenty-four species of prey items in fosa scats and observed that, in addition to being the only significant natural predator for lemurs, the fosa has a remarkably plastic diet. Based on a trapping study in the Kirindy Forest in northwest Madagascar, Hawkins and Racey (2005) estimated the fosa's population density to be 0.26 individuals per square kilometer, a number normally attributed to carnivores five times the size of *C. ferox*.

Because of the fosa's wide, highly carnivorous and generalist diet, it has a disproportionate impact on its environment relative to its abundance. Therefore, it may be considered a keystone species, underscoring the importance of its protection. Extirpation of top predators may lead directly to major ecosystem changes, primarily in regard to biodiversity (Glen et al., 2007; Johnson et al., 2007). The release of prey species may lead to increased prey abundance, subsequent unhindered competition, and the eventual displacement of the less successful species – resulting in extirpations potentially promulgating further extinctions. Lower level predators, unchecked by an apex carnivore, may attain high abundance which could lead to extirpation of their prey, a problem known as mesopredator release. Both of these scenarios lead to the loss of biodiversity through the mismanagement or stochastic impact on a single keystone species.

Due to its range and low population density, the fosa will be one of the species most harmed by habitat loss and fragmentation. The small size of the remaining populations indicates that the fosa is sensitive to environmental stochasticity. The presence of additional pressures may be the deciding factor between recovery and extirpation. The competition imposed by invasive carnivores is one such

pressure and, although it is not the primary danger which threatens the fosa's continued presence in Madagascar, it is significant. The precipitous position in which the fosa now rests requires direct and efficient action in order to save it from extinction. Quantifying this conflict will be the first step in introducing control measures for stray and feral dogs in the forests of Madagascar. Further, the recognition of a new and important pressure on the fosa could provide further support for its classification as Endangered under the IUCN Red List.

EXPERIMENTAL DESIGN AND METHODS

The effect of the feral dogs was investigated as part of an ongoing experiment conducted in Ankarafantsika National Park, Madagascar over the last decade. The park contains 65,520 ha of dry deciduous forest, a part of the larger Ankarafantsika reserve complex. The Ankarafantsika reserve complex is one of Madagascar's largest tracts of forest and comprises approximately 200,000 ha (Dollar et al., 2006), including buffer regions. The fosa is commonly known to inhabit this forest and anecdotal evidence from the park staff suggests that dogs have been present in the forest since 1999.

Ankarafantsika is also home to a rare subspecies of the falanouc (*Eupleres goudotii major*), another at-risk Euplerid carnivore.

Trapping took place between the years of 1999 and 2008 using both Havahart and Tomahawk live traps, all baited with zebu or chicken meat. The meat ranged from fresh to rotten, but was replaced whenever it became completely desiccated, covered or inhabited by invertebrates, or when it was no longer intact enough to remain in the trap. Three trap lines were chosen, each within a few kilometers of Ampijoroa Research Station. The first trap line was placed in an area known as Jardin Botanique A, a section of forest south of the research station. The next trap line was set out in Jardin Botanique B, north of the research station, near Lac Ravenloc. Due to restrictions on research imposed by the park service, the trap lines had to follow existing trails through the park. Each trap was placed as directed by

the principal investigator, Dr. Luke Dollar, in order to maximize trapping efficiency and the number of habitat types covered. The third trap line was placed on the boundary line between the section of forest containing Jardin Bonanique A and the savannah. This line was included in order to capture carnivores which may be residing in the savannah but preying on species on the edges of the forest.

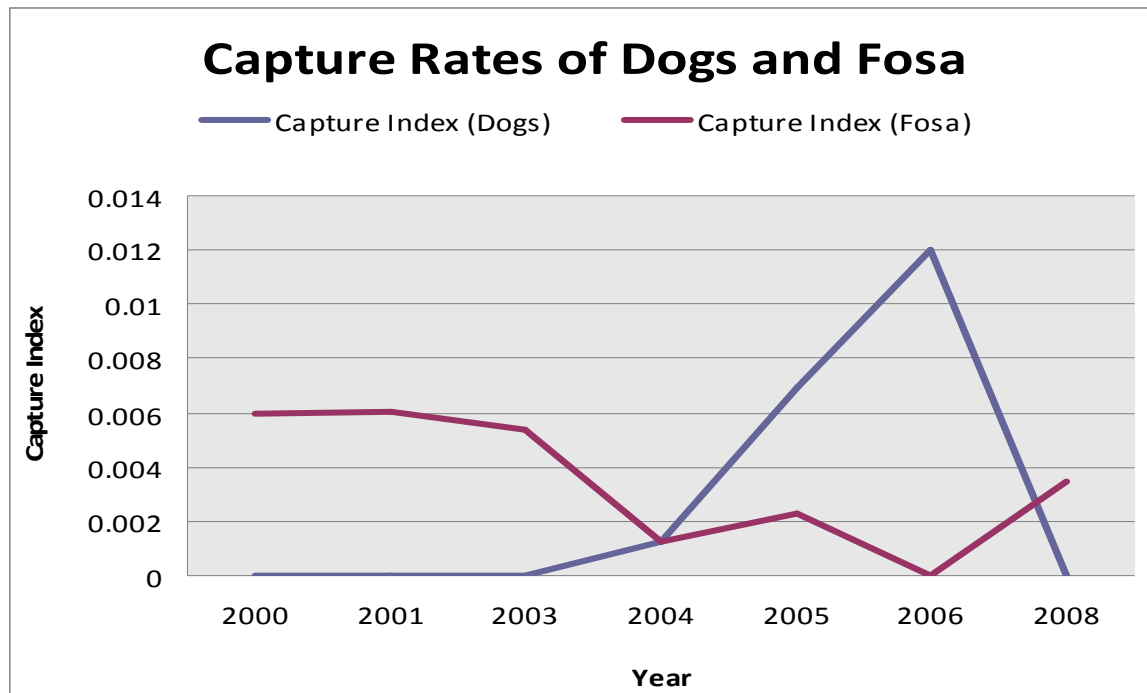
The traps were checked twice a day by project staff member and a number of volunteers, once early in the morning and once in the late afternoon, just before nightfall. In addition to checking for captures, resetting and baiting the traps when needed, each trap check was also a census walk. All wildlife seen were recorded and identified by species. When species identification was not possible, distinguishing characteristics of the creature were recorded and, when possible, pictures were taken for future identification. In the event of a capture, one of the staff members would tranquilize the animal and it would be taken back to the project headquarters in Ambodimanga. After receiving the capture, the principle investigator would take morphological measurements and scan for identification tags in order to record recaptures. Veterinary data were also recorded by the team veterinarian, Dr. Julie Pomerantz, to judge the health of the animal and the presence of infectious diseases. Once all data were recorded, captured dogs were euthanized at the request of Park management. All other animals were returned to the area where captured and then released.

The number of captures of dogs and fosa during each trap year was divided by the number of days that the traps were baited and set. This resulted in capture rates, controlling for differing trapping effort in each year.

RESULTS

Trapping did not take place in 2002 or 2007. Also, data from 1999 were not included in the analysis as this was a pilot year and capture rates would not be as reliable as in subsequent years. Over

the course of the study, 19 fosa and 8 dogs were captured. Other carnivores, such as cats (*Felis catus*) and small Indian civets (*Viverricula indica*) were also captured but not included in this discussion.



DISCUSSION

Competition with the Fosa

The relative capture rates of fosa and dogs clearly show an inverse relationship. The capture rates for fosa in 2000 and 2001 were nearly identical. The drop in capture rates in 2003 is small enough to be attributable to nearly any factor – variability in trap locations, population stochasticity, etc. But, in 2004, with the first capture of dogs, the capture rates of fosa declined dramatically, to a level 22% of what it was in the previous year. Capture rates increased for both animals in 2005 and they reached their most dramatic levels in 2006 where we found the highest capture rates for dogs and, for the first time in the study, no captures of fosa.

The zero capture rate for fosa could mean a temporary extirpation brought on by dogs. It is unlikely that the dogs directly killed any of the fosa, but rather that they excluded them from the study

area through consumptive and encounter competition (Schoener, 1983). Consumptive competition occurs when a competitor consumes enough of a resource to cause harm to another individual. Highly overlapping diet frequently leads to negative correlation in population densities, as seen here (Creel & Creel, 1996). Encounter competition occurs when interactions between mobile individuals leads to harm, in this case through the loss of time and energy. Studies have shown that, due to predator avoidance and exclusion competition, foxes are rare where introduced dogs are abundant (Mitchell & Banks, 2005). These are both mechanisms by which the invasive dogs are affecting *C. ferax* in Ankarafantsika, and both could be contributing to the current behavior of the fosa population.

The natural behavior of the fosa lends credence to the encounter competition hypothesis. The fosa is notoriously solitary and vigilant. Original efforts to track the creature with radio telemetry resulted in the active evasion efforts of the fosa, staying ahead of the trackers by kilometers (Luke Dollar, personal communication). Based on this, it is likely that the dogs are seen as unwelcome intruders by the fosa and, because of the large size and noisiness of dogs, the fosa may be actively avoiding them. This form of encounter competition would harm the fosa through opportunity costs, and explain the negative spatial correlation, but would be much less harmful to the ecosystem as a whole than other effects of invasive dogs.

Since the introduction of dogs to the park, sightings of ground animals, such as ground-nesting birds and rodents, have dropped to as much as a fifth of what they were before the invasion (Luke Dollar, personal communication). If the sharp decline in prey populations can be attributed to the arrival of dogs, it would be a clear case for consumptive competition. Until data can be presented as to the habits of feral dogs in western Madagascar, strong support for this hypothesis can be drawn from similar cases of dog invasion. Native wildlife, especially on island habitats, has historically been very sensitive to the introduction of domesticated carnivores. Dogs are generalists, able to survive on food items from all trophic levels. Feral dog studies in the United States have shown that dogs consume deer,

song birds, rodents, beetles, fruit, leaves, grass, and garbage, as well as a variety of domestics, such as poultry (Gipson & Sealander, 1976; Scott & Causey, 1973). Studies regarding the food habits of the fosa have demonstrated considerable overlap, showing that the fosa preys on lizards, amphibians, birds, and mammals, and that it famously includes lemurs in its diet (Dollar, 2006; Hawkins & Racey, 2008). In essence, both dogs and fosa feed on anything that they can get their hands on. Regardless of the dietary overlap, however, dogs have been known to be damaging to animal populations by their very nature. Roaming dogs which encounter livestock are often liable to injure or mortally wound the creature without feeding on it, often appearing as though they were “involved in vicious play” (Green & Gipson, 1994; Van’t Woudt, 1990).

Overall, wildlife populations are ill-adapted to defend against invasive dogs. The history of iguanas (*Amblyrhynchus cristatus*) on the Galapagos Islands has shown just such a case (Kruuk & Snell, 1981). Marine iguanas have evolved behaviors which have made them fairly successful in avoiding capture by Galapagos hawks (*Buteo galapagoensis*), causing them to stay close to refuges of rocks and crevices during the day, the period in which the hawk hunts. But at night, while the dogs are on the prowl, the large male iguanas sleep exposed on the surface of the island. This was presumably a territorial defense mechanism, allowing the iguanas to control their mating area, but also allowing the dogs unfettered access to the vulnerable males. The authors of the study found at least one population exploited past recovery during the study period and suggested that subsequent populations would experience radical decline unless the Galapagos dogs were eliminated. A particularly shocking study in New Zealand found that a single female German Shepherd, stray and roaming in a forest for a several weeks, killed an estimated 500 kiwis out of a population of 900. None of the kiwis found had been even partially eaten; autopsies lead to the conclusion that they had been squeezed to death, resulting in hemorrhaged organs (Taborski, 1988). Even if the dogs are not hunting specifically for the same prey as the fosa, they still have a huge impact through incidental predation. A study in the Iberian Peninsula

found that wild dogs were the primary predator of larks, a ground-nesting bird (Yanez & Suarez, 1996). Larks, however, did not make up an important portion of the diet of the dogs. The extremely high nest mortality (approximately 90%) was a result of incidental predation, the lucky encounter of unexpected prey while searching for their primary prey, rabbits. Because the larks were not the primary target of the carnivore, their capture did not alter foraging behavior, leading to a consistent decrease in the population instead of a shift to more abundant prey. The dogs would also destroy nests when no birds or eggs were present, adding insult to injury. Ground birds are especially vulnerable to roaming dogs, possessing a defensive adaptation which entails standing still while a predator approaches. This is a beneficial adaptation against predators which hunt by sight, such as the fosa, but is useless against dogs which hunt by scent (Van't Woudt, 1990). Where a cat or similar predator will pass by without noticing the prey, a dog would easily root them out of even dense foliage.

In addition to the inability of native wildlife to adapt to their presence, dogs are able to exploit an array of characteristics which allow them to outcompete natural predators in the area. Unlike native wildlife, they remain able to utilize human resources in the vicinity. Even truly feral dogs, not aided directly by humans, can still return to garbage dumps and other sources of human refuse when natural resources diminish, thereby allowing their populations to exist above carrying capacity (Boitani, 1992; Daniels & Bekoff, 1989; Schmidt et al., 2007; Scott & Causey, 1973). If the dogs were temporarily extirpated from the area, poor domestic animal practices in nearby towns and villages will maintain a reserve pool which will soon invade the habitat again. The presence of human populations in and around the national park, in fact in the study area, gives the dogs in Ankarafantsika such an opportunity. The instinct to hunt in packs also offers a considerable advantage, especially when in an area where none of the other predators demonstrate sociality. Pack living leads to enhanced vigilance and better access to higher quality foods, increasing the survivorship of each individual in the pack while in a resource abundant area (Daniels & Bekoff, 1989). They may learn how to hunt and attack in concert, allowing

them to bring down larger or more dangerous prey than a single dog would be capable of (Green & Gipson, 1994).

It seems that the only thing keeping dogs from being able to completely outcompete the fosa is their lack of the ability to climb. The majority of lemurs, which live high in spine-covered trees, are out of their reach. One may draw the conclusion that, because the fosa has a monopoly on this prey base, the dogs couldn't be causing extirpation of the fosa through consumptive competition. But, although the fosa can capture lemurs, primates make up less than half of their diet (Dollar, 2006). Furthermore, the fosa has been shown to prefer abundant prey, having such a high impact that it limits the populations of one prey item and then switches to another with higher population numbers (Hawkins & Racey, 2008). If half of the fosa diet was to become unavailable or hampered, it is likely that the fosa would consume the remaining prey base until it were gone or until its own populations decreased to a lower level to compensate for the lack of success. This may be precisely what is happening now and a major cause of the rapid decline of *C. ferox* during the study period.

Vectors of Disease

Pathogen pollution has been cited as a major threat to global biodiversity, following only to habitat decline and invasive species (Dasak et al., 2000). The introduction of exotic pathogens is responsible for or involved in numerous extinctions (Wikelski et al., 2004). Even short of complete extinction, introduced pathogens can lead to decimation of populations, making them much more likely to be wiped out by natural pressures of stochastic events. In this case, dealing with a species which is already under enough pressure for it to be Vulnerable (IUCN, 2008), the species may already be particularly exposed to stochasticity (Clifford et al., 2006). Ecological theory suggests that populations which reside in habitats smaller or more fragmented than natural are more vulnerable to the spread of disease by being more likely to interact with the pathogens and the invasive hosts (Suzan & Ceballos,

2005). Moreover, the small populations of *C. ferox* may be more susceptible to pathogens through decreased genetic heterogeneity (Parrish et al., 1985).

Therefore, irrespective of competition between fosa and dogs and the effect of feral dogs on the prey in the park, evidence is available which reveals that dogs do have a direct effect on the survivorship of fosas. The team veterinarian for this study, Dr. Julie Pomerantz has collected veterinary data on all of the animals trapped throughout the study period. Many of the dogs were shown to be infected with diseases common to feral canids, such as canine adenovirus, canine distemper, canine parvovirus, herpesvirus, canine parainfluenza, canine coronavirus, and *Neospora caninum*. Exceptional among these diseases are canine parvovirus (CPV-2) and canine distemper (CDV) – antibodies against both have been found in captured fosas (Pomerantz, unpublished data).

Canine parvovirus has had a long and lurid history since its discovery in 1978, probably evolving out of the feline parvovirus (Parrish et al., 1985). It has been linked to the consistent decline of gray wolves and Ethiopian wolves, and it has also been found to be prevalent in large felines in Africa. In both of these instances its spread has been attributed to nearby dog populations. CPV-2 has been noted as being very stable in the environment, surviving for days in the feces of infected hosts (Suzan & Ceballos, 2005). It has also been found to demonstrate the ability to evolve quickly and has mutated several times to increase its host range (Levy et al., 2008).

The canine distemper virus has been associated with the extinction of populations of African wild dogs and black-footed ferrets and, along with CPV-2, has been a threat to Ethiopian wolves (Dasak et al., 2000). CDV is thought to be the primary cause of a mass die-off of approximately 10,000 Caspian seals in the spring of 2000 (Kennedy et al., 2000). The deaths took place over a course of only a few months, underscoring the deadly potential and rate of transmittance of the virus in naïve populations. The Caspian seal tragedy mirrors a similar situation that took place in the 1980s with Baikal seals, also thought to be caused by CDV (Kennedy et al., 2000). CDV antibodies have also been detected in up to

85% of the Serengeti lion population (Roelke-Parker et al., 1996). In all of these cases, the origin of the virus is considered to be contact with domesticated dogs – roaming, stray, or kept such as those in the villages adjacent to the Serengeti.

Many of these diseases are found at much higher rates in stray and feral dogs. A study in Brazil found that *Neospora caninum*, a disease hosted by dogs which causes spontaneous abortions in cattle, was 2.5 times more likely to be found in strays than in those which are still owned and cared for (Gennari et al., 2002). Native populations in shrinking environments, similar to those encountered in nearly any tropical environment, can often even cause these pathogens to become more virulent than normal through increased rates of contact and contraction (Suzan & Ceballos, 2005). Through evolution and mutation, all of the pathogens encountered by naïve populations have the potential for the restructuring of food webs. Initial contact can lead to major depopulation and, if the pathogen gains a foothold in the species, population depression can be a constant symptom. Further, if the threshold density for transmission is diminished, or if environmental stochasticity lowers the population enough, the pathogen can lead to local extermination (Dasak et al., 2000). CDV and CPV-2 have already shown this capacity.

Feral mammals have been cited as the main pool of infectious disease in reserves in Mexico (Suzan & Ceballos, 2005), and it would be surprising if this were not the case in other areas in which stray and feral dogs have led to the contamination of natural wildlife. We cannot expect the diseases to eliminate these carriers by themselves – populations of dogs have been decimated by disease and have rebounded back to previous levels in staggering amounts of time. A population of 300 dogs in the Galapagos was decreased to 30-40 individuals by an outbreak of CDV and returned to 197 individuals in a census 15 months later (Levy et al., 2008). These outbreaks are cyclical (Clifford et al., 2006) and, if they can destroy the populations of canines that effectively, the principle of precaution forces us to assume that the same can happen to other populations which are be infected. The difference will be

that the fosa, unsupported by humans, lacking sociality, and living in wide-ranges, will not be able to bounce back.

The spread of invasive diseases also has an economic cost, one which will be very difficult for the villagers in Ankarafantsika, the people at risk, to pay. In the United States, \$1.1 million was paid for post-exposure treatment after 665 people had been potentially exposed to rabies by one kitten. The total cost of introduced pathogens on humans, livestock, and crops in the United States alone is estimated at around \$41 billion. In Australia, an invasive pathogen had such an effect on sardine fisheries that it cost approximately A\$12 over three years (Dasak et al., 2000). These are costs which are independent of biodiversity loss, or the ripples which can arise from the loss of a species, although studies have shown that biodiversity is inextricably wound within the world's economy (Arrow et al., 1995; Costanza et al., 1998).

MANAGEMENT IMPLICATIONS

Stray and Feral Dog Control

Green and Gipson (1994), in an article detailing how to control wildlife damage from feral dogs, suggest several management possibilities: frightening, repellents, toxicants, trapping, shooting, and fencing. These suggestions are geared toward protecting livestock and poultry and, therefore, some are incompatible with use in a national park where their effects on native wildlife need to be taken into account.

The use of visual and auditory devices to frighten the dogs away from areas in which they may cause damage is viable when there are small and blatant areas that need to be protected, such as pens, but not in an area as large as Ankarafantsika. Devices which frighten domesticated animals, which are used to the effects of humans, will certainly have a larger impact on wildlife and will disrupt their natural lifecycle. Repellents are used to keep dogs from creating scent stations and territories, thereby lowering

the use of the area by subsequent domesticated animals. This is not a proper preventative measure as it does not exclude the presence of dogs, but only partially limits it. Moreover, because the repellents have not been tested for effects on the wildlife of Madagascar, it may exclude natives from areas we wish them to establish. Fencing is equally inappropriate for similar reasons. Not only would it be improbable to fence the entire park to keep out invasives, several villages exist within the boundaries of the park and, because of the relationship between people and domesticated animals, a fence would be useless.

Toxicants are perhaps the worst solution available due to the potential for incidental poisoning. Poisons have been used to protect sheep from coyotes (Connolly & Burns, 1990; Gustavson et al., 1974), and have been shown to be successful in producing both aversion from attack and the death of the predator. In the former case, a sheep carcass may be injected with lithium chloride to produce sickness in the coyote which scavenges from the carcass, thereby preventing further attacks on sheep. But this does not prevent the predator from attacking other prey in the area. In the latter, sheep are fitted with collars which may be torn open during a predator's attack or while feeding, releasing the poison and killing the predator. This is a very target specific method, but requires a large, controlled prey, such as livestock, and requires that the prey is killed in order to kill the predator. Toxicants were used successfully to control dogs in the Galapagos (Barnett, B., 1986), where a poison exceptionally selective for canids was injected into meat and the meat was placed for consumption by the dogs. In this instance, however, the researchers did not have to contend with other large carnivores. These methods are inappropriate for use in Madagascar because a) there is no specific prey target that needs to be protected from dogs (because nearly all prey in the area are likely to be taken), b) there is no prey item which presents itself to be fitted with a collar, c) all of methods leave toxins in the environment to be consumed by other carnivores, and d) to my knowledge, the selectivity of commonly employed poisons has not been tested with Euplerids. The fosa is known to eat rotten meat and carcasses, offering a

significant possibility of consuming any poison intended for dogs. The fact that the fosa is a voracious eater and often consumes the entire carcass of even its larger lemur prey, indicates that even extremely selective poisons may present a hazard. The falanouc, another Euplerid carnivore in the area, and lemurs, who may come into contact with the toxins out of curiosity, are also vulnerable to incidental poisoning. Because the primary reason for controlling the feral dog population is to aid in the recovery of the native wildlife in Ankarafantsika, a toxicant related control program cannot possibly be recommended.

Trapping, as shown by this study if nothing else, is an effective way to catch the feral dogs. The dogs may then be transported elsewhere, neutered, or euthanized. Transporting and euthanizing the animals would immediately stop them from damaging wildlife; neutering them would cause the decline of the population over time. If a fosa or other native animal is trapped, incidental harm may be avoided by using wildlife safe traps. However, trapping is not as safe as it appears on the surface, as even wildlife safe traps such as the Tomahawk-style and Havahart-style which were used in this study can pose a danger to *C. ferox*. The fosa is wild and quite high strung; they have been found to wound themselves through attempting to squeeze through narrow openings in the cage and cutting themselves, bashing their heads into the cage door and causing skull fractures, and by chewing directly on the cage and shattering teeth. Unless trapped, approached, and sedated by people who are experienced with techniques to avoid this, there is a significant risk to the fosa being harmed or killed. Euthanizing or neutering dogs, either chemically or surgically, is both expensive and requires specially trained persons capable of performing the procedure. A trap-neuter-release campaign may take too long to take effect, making it incompatible when used in a sensitive ecosystem with vulnerable or endangered species, and it would not prevent disease transmission or wildlife predation (Schmidt et al., 2007).

Trapping is a moderately attractive option, given time and available skill, as it is capable of immediate and target-specific action. But, that technique skirts another which is far more efficient. Hunting of the unaccompanied stray and feral dogs by park staff or volunteers would extirpate the dogs from the area in a short time with a fairly unobtrusive campaign, and removal of the dead animals will substantially reduce the risk of pathogen poisoning. Although the loud noise of the guns may mildly disturb wildlife, due to the low density of the dogs in the park at present it will not be continued long enough to cause significant changes in habit. The frightening method, by contrast, must be continually employed to have any appreciable effect. Volunteers can be given short and informal instruction on distinguishing dogs from native wildlife, which is certainly not difficult, in order to ensure an almost nonexistent likelihood of accidental kills. The possibility of the park staff, whom are Malagasy natives, accidentally shooting a fosa or other native mammal instead of a dog is so remote that it borders on the absurd. Further, in exchange for the substantial cost of employing carnivore traps, which requires baiting and checking for captures twice a day in order to release non-target captures, the only materials necessary for this method are bullets and a rifle. Surveying the park for the presence of dogs would be required at intervals depending on the rate of invasion, perhaps only once a month. The removal of dogs by this method could become a normal part of the park staff's monitoring procedure. The cost of this control measure in money, time, and danger to wildlife, is extremely low compared to the other options available.

If it becomes necessary to increase the speed of the removal, or to find dogs which are not being found by the park staff, radio collars may be affixed to trapped dogs which would then be released. The high sociality of dogs enables this dog to lead to others which are in the area (Green & Gipson, 1994). But, because most of the dogs still maintain contact with the adjacent villages, and because Ankarafantsika is well-travelled by the Malagasy people, I do not envision this additional expense being necessary. The last 5% of a feral population is the most difficult to remove (Barnett, B.,

1986), but with the control of re-invasion from villages, dogs will be extirpated from the park or reduced to a level of causing no harm within a few months, depending on the consistency of the removal program.

Long-Term Solutions

Regardless of the control method, long-term solutions to the stray and feral dog problem will be necessary, and should be considered in all areas where domesticated animals are present. The disposal of garbage and other human waste-products must be done in a manner which doesn't allow access by stray and feral carnivores, such as by fencing dumps or burying the waste in a sanitary landfill (Barnett, B., 1986; Green & Gipson, 1994). Removing local livestock and poultry is not appropriate in areas such as Ankarafantsika, where people rely on the forest to feed the livestock, and the removal of humans from native humans from the area should certainly not be considered. Caging or fencing poultry and livestock would decrease the chance for predation by feral and wild animals, but would also cause concentrated ecological damage by the livestock, exchanging one environmental harm for another.

The continual reproduction of unwanted domesticated animals must be prevented (Barnett, B., 1986; Green & Gipson, 1994). The growth of stray populations in cities and villages which are near natural areas increases the chance of stray animals invading (Kruuk & Snell, 1981). Education of the public, especially those who inhabit these sensitive areas and national parks, as to the harm that domesticated carnivores can cause is the first step. This should be followed by education regarding the proper methods for care and control of domesticated animals, such as campaigns to spay and neuter domesticates which are owned, and euthanize those that are already stray in cities. Laws and regulations which prohibit the abandonment of domesticated animals, and hold the dog owners responsible for damage, are also a necessary step to ensuring proper treatment of domesticated animals and to prevent further ecological destruction (Green & Gipson, 1994).

As mentioned before, the presence of invasive domesticated animals is not the only issue plaguing the fosa. Although the resolution of the invasive animal problem would be helpful, it would not do away with the potential for extinction altogether. All of the current threats to the fosa can be addressed simultaneously by boosting its national image (Boitani, L., 1992). *C. ferox* suffers from stereotypes, accusations, and myths. When a villager in Ankarafantsika loses a chicken, it will often be assumed that a fosa killed it, though no evidence suggests that being the case. Because the poultry are free-roaming in the villages and along the edges of the forest, it is possible that a fosa was the predator – but it is equally if not more probable that a dog or another villager took it. Further, they are seen as vicious creatures, sometimes invoking such fear in Malagasy villagers as to lead them to kill the fosa on sight.

In fact, the fosa is perhaps one of the greatest friends of the Malagasy farmers in Ankarafantsika. By its nature it controls the rodents and feral pigs in the park which destroy crops and ruin harvests. If the truth about the ecology of the fosa can be spread, not only would it cease the pointless persecution of the creature but it would also be the first step toward widespread national campaigns to save it from extinction. The unique qualities of the fosa make it a prime candidate for such a campaign; its image can be a powerful representation of Madagascar, and when it can be seen as a symbol of the nation, measures to reduce its threats (deforestation, habitat loss, fragmentation, invasive species, etc.) will not only be more likely to begin, but more likely to come to fruition.

SUMMARY

Given the varied and devastating effects of these domesticated carnivores, the control of stray and feral dog populations should be one of the primary concerns of wildlife managers in areas where they exist. Not only do they continually chip away at the biodiversity of an ecosystem by killing animals, seemingly for pleasure and without, they carry with them the possibility of sudden and catastrophic

ecological damage through invasive pathogens. This has been shown to happen many times and in diverse ecosystems – it comes as a shock that more energy is not concentrated at alleviating this problem given its propensity for damage, anthropogenic origin, and relatively straightforward solution.

Madagascar is just one such area where invasive domesticated carnivores are a problem. But, because it is a biodiversity hotspot with such high rates of endemism, efforts should begin in fervor there. The timely control of these stray and feral dogs in Ankarafanstika and the successful promotion of the national image of the fosa would not only help to save this unique creature, but it could set the stage for a windfall of conservation achievements in Madagascar and in similar ecological communities across the globe.

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