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Mixed-breed guarding dogs reduce conflict between goat herders and native carnivores in Patagonia

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Abstract: Goat husbandry is the main rural livelihood in the northern Patagonian steppe of Argentina, and herders kill any carnivore that they believe threatens their herds, including the endangered Andean cat (*Leopardus jacobita)*. We evaluated the use of local, medium-sized, mixed-breed guarding dogs to reduce predation and retaliatory killing of carnivores. We interviewed 64 herders, and delivered 37 puppies to 25 herders. Most economic loss was attributed to cougars (*Puma concolor*) and culpeos (*Lycalopex culpaeus*). All herders with dogs that reached the working stage reported reduced rates of predation, and 88% reported that they no longer kill carnivores. Among herders who were not using dogs, 89% of them reported increased predation, and 100% of them confirmed that they kill carnivores. Mixed-breed dogs can be effective in reducing both predation losses and retaliatory killing, but their success depends on the ability and willingness of herders to train and use them properly.

Key words: Andean cat, Argentina, culpeo, human–wildlife conflicts, livestock, guarding dog, predation, puma

THE NORTHERN PATAGONIAN steppe of Argentina harbors a diverse carnivore community, including 5 species of felids—cougar (*Puma concolor*), jagaurundi (*Puma yagouaroundi*), Geoffroy's cat (*Leopardus geoffroyi)*, pampas cat (*Leopardus pajonal*), and Andean cat (*Leopardus jacobita*), and 2 species of canids—culpeo fox (*Lycalopex culpaeus*) and chilla fox (*Lycalopex chilla*). The Andean cat is an endangered species, and its Patagonian population is genetically and ecologically distinct (Villalba et al. 2004, Novaro et al. 2010, International Union for Conservation of Nature and Natural Resources [IUCN] 2011, Cossios et al. 2012). Geoffroy's and pampas cats are classified as near threatened, and puma, jaguarundi, and the 2 canids are species of least concern (International Union for Conservation of Nature and Natural Resources [IUCN] 2011). The Andean and Geoffroy's cats are on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I, and all other species are on CITES Appendix II (United Nations Environment Programme-World Conservation Monitoring Centre 2011).Cougars were extirpated from the region in the 1900s, but recolonized within the last 20 years.

Husbandry of goats is the main livelihood of rural people in the area, but the practice is threatened both by desertification from decades of overgrazing and a trend of declining precipitation and increasing temperatures due to global climate change (Lauenroth et al. 2004, Vera et al. 2006). In addition, herders report increasing losses of goats from predation, and herders kill any carnivore that they believe threatens their herds. Most of the records of Andean cats, since they were discovered in the steppe during 2008 are of cats killed by

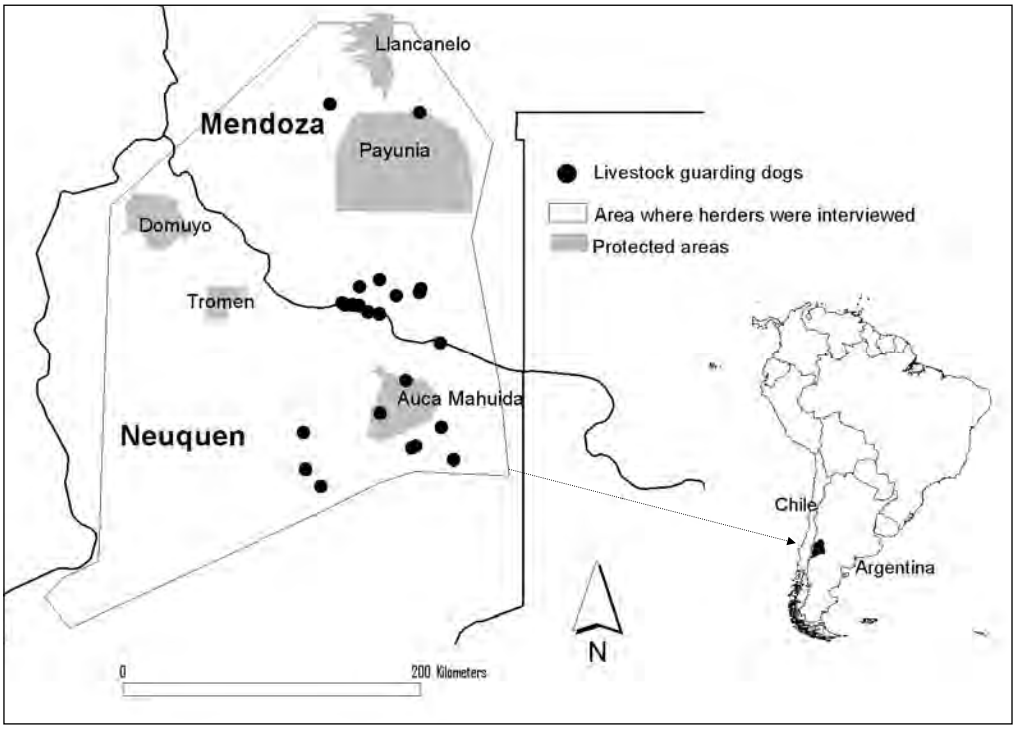

Figure 1. Location of study area in Mendoza and Neuquén provinces, Argentina, where interviews were carried out, sites where livestock guarding dogs were used, and provincial protected areas. Inset shows location of study area in South America.

goat herders (Martinez et al. 2008, Novaro et al. 2010). Therefore, both the preservation of the livelihood of these low-income herders and the conservation of the diverse carnivore community, especially the endangered Andean cat, depend on developing effective methods to reduce predation losses and retaliatory killing of carnivores.

Livestock guarding dogs have been used for at least 6,000 years (Rigg 2001) and have been shown to be effective in reducing predation on sheep by canid predators and bears (McGrew and Blakesley 1982, Andelt and Hopper 2000, Rigg et al. 2011). For most of this time, dogs used for guarding livestock were simply selected from among locally available dogs that showed appropriate behavior (Rigg 2001, Coppinger and Coppinger 2005, Gehring et al. 2010*a*). Today, there are almost 40 specialized breeds that were developed in different parts of the world for this purpose. These large-bodied, purebred dogs have been the subject of numerous reviews and evaluations of their use and efficacy, based largely on reports by producers using the dogs (McGrew and Blakesley 1982, Coppinger et al. 1988, Green and Woodruff 1988, Rigg 2001, Marker et al. 2005, Otstavel et al. 2009).

However, large-bodied, purebred dogs are not practical for goat herders in northern Patagonia because these herders cannot afford them. Mixed-breed dogs are used successfully as livestock guarding dogs by Navajos in the southwestern United States (Black 1981, Black and Green 1984), and their use has been reported in some other places (Black and Green 1984, Coppinger et al. 1985, Rigg 2001). We found that a few goat herders in northern Patagonia were also using local, mixed-breed dogs to guard their herds, some with support of the Department of Renewable Natural Resources of the province of Mendoza. We initiated a pilot project to expand the use of these dogs to herders and to evaluate their efficacy in reducing predation on goats and retaliatory killing of carnivores. These medium-sized (15 to 18 kg) dogs are products of generations of selection for the local environment, are free or inexpensive to obtain, and do not require as much food as the larger, purebred guarding dogs. We report results of this pilot project carried out from 2005 to 2011.

Methods

Study area

The project took place in the northernmost portion of the Patagonia region of Argentina, in the provinces of Mendoza and Neuquén (Figure 1). Topography includes old volcanic cones, high plateaus, and plains. The habitats are mixed grass-shrub steppes, and the climate is dry and cold, with frosts nearly year-round. January is the hottest month, with a mean maximum temperature of 30.5° C, and July is the coldest month, with a mean minimum of 0.7° C. Annual precipitation averaged 142 mm (SD = 83), 84 mm (SD = 85), and 135 mm (SD = 42) at 3 different weather stations within the study area between 2002 and 2010 (Autoridad Interjurisdiccional de Cuencas, <www.aic.gov.ar>).

The rural population has declined over the last 30 years (15% between 1990 and 2000), while cities and towns have grown (28% between 1990 and 2000; Instituto Nacional de Estadística y Censos 1991, 2001). The region has been subject to intense activity by oil companies for several decades, and since 1993 has produced 42% of the oil and 55% of the gas in Argentina (Instituto Argentino del Petróleo y el Gas, 2012).

Herder interviews

From 2005 to 2011, we interviewed 64 herders in an area of approximately 57,000 km^2 about predation on their livestock by different carnivore species; economic losses to predation; and management, size, and composition of herds. Because our primary purpose was to reduce conflict between goat herders and carnivores, interviews were concentrated in areas of conservation importance for the Andean cat or areas important for other wildlife where conflict with pumas and culpeos was high and herders requested our assistance or assistance from government agencies to reduce predation on their goats. Therefore, the results may not represent the full range of situations in this large area. The interviews were semi-structured, face-to-face interviews carried out at the herders' homes, and we did not obtain responses to all questions from all of the herders interviewed. Sample sizes (*n*) for results presented are based on the number of interviewees from which we obtained a response for that question.

During these interviews, we identified 25 herders who were willing to try out mixed-breed livestock guarding dogs to protect their goats. After the first dogs were working, we produced a video featuring herders successfully using dogs to explain their training and use to other herders. The video was particularly effective in recruiting additional herders to use dogs. All 25 herders who received dogs were interviewed about the behavior of the dog during monthly or bi-monthly visits during the training period. The herders with dogs that successfully reached the working stage were subsequently interviewed about the dogs' behavior, their satisfaction with the performance of the dogs, trends in depredation losses, and additional methods of predation control that they used. A control group of 9 herders in the same area that was not using guard dogs was also interviewed about trends in predation losses and methods of predation control used.

Figure 2. Mixed-breed puppies that were born within the area shortly before the birthing period for goats were delivered to herders.

Care and training of guarding dogs

Care and training of puppies raised to be livestock guarding dogs was based on protocols used in other areas (Black and Green 1984, Rigg 2001) and the experiences of the Department of Renewable Natural Resources of Mendoza with local herders. To be effective guarding dogs, the puppies must develop adequate trustworthy, attentive, and protective behaviors during the first year of their life (Coppinger et al. 1988). Training of puppies is oriented toward fostering these behaviors at critical stages in their development. We obtained mixed-breed puppies born within the area shortly before the birthing period for goats and delivered them to herders who placed them in corrals with their

goats (Figure 2). Puppies too young to eat solids were fed on goat milk and assisted with nursing directly from the nanny goats until they were big enough to do so themselves or to eat solid foods (Figure 3). Herders were instructed to keep the puppies in the corral with the goats at all times and to minimize contact with humans, restricting necessary contact for assistance in feeding and care to only 1 person. Adult goats were released during the day to forage, and puppies remained in the corral with kids until both reached 4 to 6 months of age. Then, puppies and kids accompanied the adults to forage on open range, with few or no fences. This style of management of goats during the birthing period was already practiced by these herders. Only herders who were willing and able to corral their goats at night for the first 4 to 6 months after the kids were born were provided with puppies. Dogs were fed herders' leftover food scraps, rice, or polenta, and occasionally commercial dog food. Once the puppy began to range with the herd, the herder had to take food to the dog every day.

We provided veterinary care, vaccinations, and deparasitization during the first 3 months after delivering the puppies and every 6 months thereafter. We spayed 3 females at the request of the herder. During these monthly visits and subsequent follow-up visits, we observed the behavior of the dogs toward people, goats, and other dogs, and we interviewed the herders to determine if training was successful and if puppies were developing appropriate behaviors for guarding dogs.

We estimated the annual cost to a herder to maintain a dog based on the costs of drugs for annual deparasitization and vaccinations, fuel for 1.5 visits per year to a veterinarian, and the amount of rice, noodles, meat, polenta, and commercial dog food needed to feed a 15- to 18-kg dog for a year. For other dogs, herders generally administer parasite medications and vaccinations themselves and rarely resort to veterinary care. However, we included 1.5 visits to a veterinarian per year, assuming that herders may be more likely to seek veterinary care for these dogs that are providing them with an important service. Daily cost of food for dogs was based on current market value of 1 kg each of rice, noodles, meat, polenta, and commercial dog food, divided by the number of days; this amount of food would feed the average-size guarding dog 29 days. True expenditures of herders on maintaining dogs are probably less than we estimated, as herders rarely buy special food for the dogs, using mostly leftover food and unused portions of slaughtered livestock. We evaluated differences between puppies that became good livestock guarding dogs and those that did not with a Mann-Whitney U test to compare the age at which a puppy was delivered to a herder and a Fisher's exact test to compare the sex of the puppies.

Figure 3. Puppies too young to eat solids were fed on goat milk.

Results

Level of conflict

Goat herds averaged 731 goats (SD = 1144, n = 37), and herders estimated a mean annual loss to predation of US $2,446 (SD = 4047, n = 64). These costs represented an average of 9% (SD = 13, n = 38) of their capital in livestock, but ranged up to 63%. Economic losses were attributed mostly to cougars (64%) and culpeo foxes (10%), with 25% to unidentified carnivores, and an average of <1% to the small cats and the chilla fox combined (n = 64). Of 44 herders who responded to a question about what they did to limit losses to predation, 36% said they used some form of lethal control of predators, 27% corralled their goat herds at night, 11% corralled their herds during the birthing period, 14% used some other form of nonlethal control, and 11% did nothing.

Guarding dogs

Between 2005 and 2011, we delivered 37 puppies to be raised by the 25 herders who chose to experiment with the use of guarding

dogs. As abundance of predators are spatially clustered, there was some clustering of herders willing to use the dogs. Each herder was given only 1 puppy per year, but some of the 25 herders received a puppy in >1 year. The sex (21 males and 16 females) of the puppy assigned to a herder was determined by availability of puppies of the appropriate age. As we did not recommend these dogs for large herds, the mean number of goats belonging to herders who were given puppies was lower ($\bar{x}$ = 379, SD = 184, range 53–750) than the overall mean herd size. The mean age at which puppies were delivered to herders was 27 days (SD = 19). Ten herders successfully raised 16 puppies to the working stage. Of the 17 puppies that did not reach the working stage, twelve failed to bond with the goats, three died during the training period, one herded rather than guarded the goats, and in 1 case the herder decided during the training period not to use the puppy as a guarding dog. The most common cause for failure of dogs to bond with goats appeared to be too much contact with humans (8 of 12 puppies). In addition, two of the 12 puppies that did not bond with goats were not kept with the goats, and one was placed with the goats at 3 months, which is the upper limit of the age for forming social attachments (Rigg 2001). There was no difference (Z = -0.76, P = 0.46, n = 27) in age of puppies at delivery to herders that did not adequately bond to goats (median = 13.5 days, n = 12) compared to that of puppies that did bond to goats (median = 17 days, n = 16). There was also no difference in the sex of puppies that became good working dogs compared to those that did not (Fisher's exact test, 2-tailed P = 0.47, n = 31).

Of the 16 dogs that reached the working stage, eleven became successful guarding dogs. The remaining five developed behavioral problems, with 2 dogs not staying with the herd (lack of attentive behavior), two attacking goats, and 1 dog herding rather than protecting the goats. Nevertheless, the herders considered that the dogs were being appropriately protective. Thus, of the 16 dogs that reached the working stage, fourteen demonstrated trustworthy behavior, fourteen were attentive to the herd, and all sixteen provided protection to the herd that was acceptable to the herder (Figure 4). Mortality of working dogs was 38% before 27 months of age (range 6 to 27, $\bar{x}$ = 13 SD = 7, n = 6). Two dogs were run over by cars, one was killed by feral dogs, one was killed by a neighbor, and two were killed by the herder when the dog began to attack the goats.

Figure 4. Most of the dogs that reached the working stage developed trustworthy behavior.

Two herders had dogs that only recently began working, so we interviewed 8 herders who have had working guard dogs. All of these reported reduced losses to predation with the use of a guarding dog. Six herders reported that they no longer killed carnivores, one never killed them and still does not, and 1 herder reported hunting predators but doing so less than before. We compared these responses to those of a control group of 9 herders who were not using dogs but were neighbors of herders using dogs and had similar size herds (range 50 to 600 goats). Of these 9 herders, eight reported higher levels of losses to predation than in previous years, while one reported no change in losses. All nine continued to hunt all carnivores in an attempt to control predation, six with the same effort as 5 years ago and two with more effort. Nevertheless, only four considered that the hunting has been effective in reducing their predation losses. Five of the 9 herders in the control group subsequently requested puppies to raise as livestock guarding dogs.

The annual cost to the herder of maintaining a dog was US $ 183 ($142 for food, $3 for parasite medication, $25 for vaccinations, $12 for fuel for visits to veterinarian in nearest town), representing 7% of the cost of average losses to predation.

Discussion

We conclude that mixed-breed dogs were effective in reducing both herder perceptions of predation losses and retaliatory killing of native carnivores by goat herders. Mixed-breed guarding dogs also reduced perceptions by the Navajo in North America of losses of sheep to predation by coyotes (Black 1981, Black and Green 1984). Empirical studies in the United States have demonstrated the effectiveness of purebred livestock guarding dogs in preventing predation by coyotes (Gehring et al. 2010*b*). Effectiveness of purebred dogs against cougars, one of the main predators in Patagonia, has not been empirically demonstrated. However, the herders' perceptions of the effectiveness of mixed-breed dogs in preventing predation by culpeos and cougars are as relevant to the mitigation of the carnivore–livestock conflict as empirical evidence (Coppinger and Coppinger 2005, Marker et al. 2005). Most of the Patagonian herders were convinced that their mixed-breed guarding dogs were effective against cougars. Most of the herders who were satisfied with the performance of their guarding dogs did not kill carnivores, indicating that guarding dogs can be a useful tool in the conservation of the Andean cat and other carnivores in the region.

Purebread guarding dogs performed as well as purebred guarding dogs in the United States: >80% of dogs were trustworthy; 49 to 80% were attentive, varying according to the breed; and 74% were protective (Coppinger et al. 1988). Although methods for evaluating these behaviors varied, Anatolian shepherd dogs in Namibia were 44% trustworthy; 88% were attentive; and 71% were protective (Marker et al. 2005). A large percentage of the puppies we monitored failed to develop social bonds with the goats. This percentage was not reported for mixed-breed dogs used by the Navajos or in studies of performance of purebred dogs, although Green (1989) reported that 55% of the 93 purebred puppies placed with sheep producers in a U.S. Department of Agriculture pilot program in the western United States either attacked or killed livestock. In our study, the failure of dogs to bond to goats seemed to be almost entirely due to improper training by the herders. Therefore, individuals or organizations seeking to implement the use of livestock guarding dogs should place special emphasis on providing the appropriate opportunity for social bonding of the puppy with goats during the critical first 3 months of life. While the slightly older puppies appeared to do as well as those that were introduced before their eyes opened, it is more efficient to introduce puppies around 6 to 8 weeks of age, as they require less work for the herders and less human interaction.

Many herders who we interviewed were not willing or able to use livestock guarding dogs. The dogs need to be fed daily and need access to water. Herders who do not corral their stock at night (73%) need to visit the herd to feed the dog on a daily basis. Some areas are very dry and have no permanent water. Also, large herds spread out too widely on the open range, making it impossible for a dog to effectively guard the entire herd. Rugged areas, where goats disperse and become separated by topographic features (e.g., some goats on top of a cliff, others on the slope, others below the cliff), may also make it impossible for a dog to adequately monitor.

Andean cats appear to be most common in more rugged areas where, as described above, the use of livestock guarding dogs may be difficult or impractical. Therefore, they cannot be the only option employed for the conservation of this endangered species, especially where the need to stop their killing is particularly urgent. Nevertheless, mixed-breed guarding dogs may be a useful tool for mitigating conflict with this and other native carnivore species where environmental conditions permit, the system for managing goats is compatible with the training needs for puppies, and herders are willing and able to invest the time, money, and effort required to properly train and maintain the dogs.

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