Techniques and Technology Note

Hair Snares for Noninvasive Sampling of Felids in North America: Do Gray Foxes Affect Success?

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ABSTRACT Hair-snare sampling has become a popular technique to assess distribution and abundance of felids. Using standard hair-snaring protocols, we sampled for margays (*Leopardus wiedii*) in Mexico and mountain lions (*Puma concolor*) in California, USA, without success. However, we noted a preponderance of gray fox (*Urocyon cinereoargenteus*) hair at sampling stations. Our review of recent literature suggests a pattern of failure to detect target felids in hair-snare surveys conducted within the range of the gray fox. We propose, among several alternative explanations, that marking by gray foxes interferes with the tendency of felids to face-rub at sampling stations. (JOURNAL OF WILDLIFE MANAGEMENT 71(6):2090–2094; 2007)

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Noninvasive sampling of free-ranging wildlife species is commonly used for species detection, individual identification, and population estimation. These techniques are useful when studying species that occur at low densities and are difficult or expensive to capture. For example, hair sampling and subsequent DNA analysis have been used to genetically tag black bears (*Ursus americanus*; Woods et al. 1999) and brown bears (*U. arctos*; Mowat and Strobeck 2000) for use in mark–recapture analysis over large areas. Similarly, hair sampling has been used to estimate population size of martens (*Martes americana*; Mowat and Paetkau 2002).

Felids are secretive and typically occur at low densities ($<1/10$ km^2) and thus represent a taxon appropriate for hair sampling. Among cats, use of scented rub pads on which individuals leave hairs is a popular noninvasive sampling method (Canada lynx [*Lynx canadensis*; McDaniel et al. 2000], ocelots [*Leopardus pardalis*; Weaver et al. 2005], Eurasian lynx [*Lynx lynx*; Schmidt and Kowalczyk 2006]). This technique takes advantage of cat cheek-rubbing behavior by using a scent lure to attract cats to a rubbing pad on which they leave hair samples. Eurasian lynx in Poland rubbed 22–46% of hair pads over multiple trapping sessions, with highest rubbing rates during the mating season in winter (Schmidt and Kowalczyk 2006). McDaniel et al. (2000) found similar success with Canada lynx in Yukon, Canada. Captive and free-ranging ocelots used scented rub pads in southern Texas, USA (Weaver et al. 2005).

We studied ecology of the margay (*Leopardus wiedii*) in El Cielo Biosphere Reserve, Tamaulipas, Mexico (Carvajal 2005, Caso et al. 2005). We could not address objectives related to seasonal habitat distribution and microhabitat preferences of margay because of a lack of margay samples collected from repeat sampling of our hair-snare sampling transect over 2 years. Hair samples from our snare stations were dominated by gray fox (*Urocyon cinereoargenteus*). A subsequent review of literature published after we began our study in September 2003 and discussion with other researchers led to our primary objectives for this paper: 1) to report the results of hair-snare studies designed to sample felids in Tamaulipas (target species: margays) and California, USA (target species: mountain lions [*Puma concolor*]), and 2) to summarize the literature on the results of felid hair-snare surveys relative to the presence or absence of gray fox.

STUDY AREA

The Mexican study area was El Cielo Biosphere Reserve, located approximately 400 km south of Brownsville, Texas, in the southwestern corner of the state of Tamaulipas. The 1,445-km^2 reserve occurs between 22°55′30″–23°25′50″N and 99°05′50″–99°26′30″W. This area was dominated by north–south trending mountain ranges composed of mostly Cretaceous karstic limestone, with most slopes exceeding 20% (Peterson 2001). Lowlands were typically humid and hot, whereas the highlands are comparatively cooler. Vegetation types included subtropical deciduous (200–800 m above sea level [asl]), montane mesophyll or cloud forest (800–1,400 m asl), and oak (*Quercus* spp.) or oak–pine (*Pinus* spp.) forest (1,400–2,200 m asl; Gram and Faaborg 1999). El Cielo had a rainy season from May or June to October, and a dry season from November to April (Peterson 2001).

The California study area comprised 3,600 ha, approximately 1,600 ha on the University of California's Landels-Hill Big Creek Reserve and 2,000 ha on the privately owned Circle M Ranch, at 36°01′30″–36°05′50″N and 121°31′26″–121°37′03″W. Both properties were bordered

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by the Pacific Ocean to the west, Los Padres National Forest to the east, and large, privately held lands to the north and south. Habitats on the study area included cool, moist redwood–tanoak (*Sequoia sempervirens–Lithocarpus densiflorus*) groves along stream courses. Oaks replaced redwoods along stream courses at upper elevations. Grasslands supplanted chaparral habitats on dry slopes such that most ridge tops are either open and grassy or oak savannah. The coastal influence was especially evident in the dry season (May–Oct) when ridges were hot and dry, but canyons were kept cool and damp by marine fog.

METHODS

We conducted 8 hair-snare surveys for margays in Mexico during the course of the study. We conducted wet-season (May through Oct) surveys in September 2003 and May, August, and October 2004. We conducted dry-season (Nov through Apr) surveys in November 2002, April and December 2003, and March 2004.

We established approximately 30 hair-snare stations at 500-m intervals along a single transect represented by the 15-km road leading from the village of San Jose at 1,400 m in altitude to the north end of Gomez Farias at 200 m. This road traversed all 3 habitat types surveyed in El Cielo: oak–pine forest, cloud forest, and subtropical–deciduous forest. We sampled habitats in a manner equivalent to their relative occurrence along the transect. We placed each station 50 m perpendicular to the transect and alternated between sides of the road.

Stations consisted of an 8×8-cm carpet pad studded with 2 rows of 2.2-cm nails through the back of the pad. We nailed pads to trees approximately 0.6 m above ground, with the nail rows oriented vertically. This design allowed the lure pad to act as a hair snag. We placed lure pasted with catnip (*Nepetu cataria*) between the rows of nails. We used a lure (Weaver's Cat Call™, St. Ignatius, MT) that was employed to survey Canada lynx in Montana, USA (Weaver 2002). In all felid species tested in captivity, including margays, this lure successfully elicited the natural face-marking behavior of felids (J. L. Weaver, Wildlife Conservation International, personal communication).

At the end of each 8-day survey session, we examined all stations for the presence of hair. If hair was present, we sealed the lure pad, including all nails, in a plastic sandwich bag. We recorded date and station number twice for each pad, once on the outside of the bag and again on a small piece of paper placed inside the bag. We bagged all lure pads individually and discarded lure pads not containing hair.

We established 36 hair-snare locations in California that we deployed from 20 June to 1 August 2003 in approximately every square kilometer in the study area. We placed each station in an area where there were cat scat or scratch marks, or good visual corridors in at least 3 directions, such as on ridge tops, at stream confluences, or at springs. If there was not a small flat area at the base of a desired tree, we built a small platform using nearby rocks, tree branches, and soil to provide a scratching area. Each station consisted of a 10×10-cm carpet pad with 10 dulled roofing nails pushed through it, with tips facing away from the backing and arranged in a circle. We nailed the carpet to a tree at a height of approximately 0.5 m with aluminum tree nails. We liberally applied Weaver's Cat Call lure to the carpet pad and sprinkled the lure with dried catnip. We suspended a flashing lure, consisting of an aluminum pie plate, by a wire above each hair snare.

We checked all stations for hair after 10–14 days, thus completing one session. We checked stations over 3 sessions, except for one station that was only checked for 2 sessions, for a total of 107 station checks. We checked hair-snare stations by returning to the station, examining the carpet pad for hair, recording the presence of hair, collecting the pad for analysis, and replacing it with a fresh one. If the pad in the first session had hair on it, the station location remained the same. If the pad did not have hair on it, but the site had evidence that cats used the area, the hair snare remained in the same location for another session. If after the second session there were still no hits, we moved the station at least 500 m from the original site.

Wildlife Genetics International (Nelson, BC, Canada) performed all genetic analyses. We also analyzed samples of blood drawn from margays in El Cielo Biosphere Reserve (Carvajal 2005) for reference. We extracted samples using QIAGEN's DNeasy Tissue kit (QIAGEN, Inc., Valencia, CA) following the manufacturer's instructions. Wildlife Genetics International determined the species of hair samples using a sequence-based analysis of the 16S rRNA mitochondrial gene (Kocher et al. 1989, Johnson and O'Brien 1997). Although specific primers and conditions were proprietary, results can be fully reproduced following procedures in Johnson and O'Brien (1997).

RESULTS

We recorded 117 hits in 250 snare-station checks during the 8 surveys in Mexico but failed to detect margay on any pad. Gray fox produced the largest proportion of hits (44.4%; 52/117). Other species that we identified from the hair samples included wolf–dog (*Canis lupus–C. familiaris*; $n = 7$), domestic cat (*Felis domesticus*; $n = 14$), goat (*Capra hircus*; $n = 1$), long-tailed weasel (*Mustela frenata*; $n = 1$), and horse (*Equus caballus*, $n = 1$). A total of 23 samples failed to produce results after 2 attempts at species identification, 8 samples were of unknown identity (of which 7 were the same identity), 1 sample matched to a human reference sample, and 3 samples were not extracted due to lack of material. Of the final 6 samples, 3 contained evidence of 2 species (all canids) and 3 were excluded based on low confidence in the results.

Sixty-six (62%) stations contained hair, whereas 41 stations (38%) did not have hair in California. Species identified from the hair samples included gray fox ($n = 52$), deer (*Odocoileus* spp.; $n = 2$), and bobcat (*Lynx rufus*; $n = 2$). Hair from 8 stations failed to produce results after 2 genotyping attempts, and 2 stations yielded mixed-hair samples. The mixed samples contained fox and coyote

Table 1. Results from published and unpublished hair-snare DNA studies targeting felids, 2000–2007.

Author and yr	Study area	Type of lure	Visual attractant	Target species	Total stations (*n*)	Hits by target species	Hits by gray fox	Success by target species (%)	Success by gray fox (%)
McDaniel et al. 2000	Yukon, Canada	5 types	Pie plate	Canada lynx	390	60	0	15.4	0
Shinn 2002	TX	Cat Call™	Pie plate	Ocelot	250	8	2	3.2	0.8
	TX	Cat Call	Pie plate	Bobcat	250	29	2	11.6	0.8
Weaver et al. 2005	TX	Cat Call	Pie plate	Ocelot	155	20	0	12.9	0
Ruell and Crooks 2007	CA	Canine Call	Turkey feathers	Bobcat	644	33	74	5.1	11.5
Harrison 2006	NM	Beaver castor and catnip	Pie plate	Bobcat	631	1	50	0.2	7.9
This study	CA	Cat Call	Pie plate	Mountain lion, bobcat	107	2	52	1.9	48.6
McRae and Beier 2000[a]	AZ	Beaver castoreum and catnip	No	Mountain lion	12	0	4	0	33.3
This study	Tamaulipas, Mexico	Cat Call	No	Margay	250	0	52	0	20.8

[a] B. McRae, National Center for Ecological Analysis and Synthesis, and P. Beier, Northern Arizona University, unpublished data.

(*Canis latrans*) in one case, and fox and an unidentified mammal in the other.

DISCUSSION

The hair-snare technique failed to detect margay although they were known to exist in the El Cielo study area. Caso et al. (2005) captured and radiocollared 8 margays (5 M, 3 F) in the cloud forest of El Cielo from June 2001 to August 2004. Carvajal (2005) also captured 14 gray foxes in the same study area. Similarly, we found mountain lion scat and scratch marks and others saw individuals throughout the California study area, but we failed to collect hair from mountain lions.

We became aware of several recently published and unpublished hair-snare studies targeting felids during and after the course of our study. Results of those studies revealed clear patterns in the success of hair-snare studies (Table 1), although no obvious differences in the lure (olfactory and visual) used in successful and unsuccessful studies were observed. In areas outside the range of gray fox or with low gray fox density, the hair-snare technique has proven successful in detecting felids. Lynx have been detected north of the range of gray fox in Canada (McDaniel et al. 2000, Weaver 2002), and Montana and Washington, USA (McKelvey et al. 2006). Ocelots have been detected in South Texas, an area of low gray fox density (Shinn 2002, Weaver 2002). However, other felid surveys within the range of gray fox generally were unsuccessful, with the predominant species detected being gray fox (Table 1). An additional unpublished study targeting jaguar (*Panthera onca arizonensis*) in Arizona, USA, over a 16-month period led to 25 samples identified microscopically as mountain lion and 23 as gray fox, but with no jaguar detections (J. L. Childs, Borderlands Jaguar Detection Project, unpublished data).

The existence of the above pattern in hair-snare studies warrants investigation of alternative explanations for the low detection of felids via the hair-snare technique within the geographic range of gray fox. One possible explanation is interference by gray fox with felid marking behavior. Like other North American foxes, gray foxes use urine and feces to scent mark on conspicuous objects (Fritzell 1987, Cypher 2005). Because canids are presumed to depend more on olfactory cues than felids (Chamberlain et al. 1999), gray foxes may likely be initial visitors to hair-snare stations. Perhaps the odor emitted from gray fox when scent marking renders the station unattractive to felids. If true, cats may approach the station out of curiosity but choose not to face-rub, which may explain scent-station results (see below). Testing this hypothesis with captive animals would be informative.

Another explanation for low felid detection rates include lack of hair-snare encounters by the target felid, although success of the technique in areas without foxes (Table 1) argues against this alternative. Our study represents the first attempt to detect margays via hair snares, and perhaps snare height was too low for this arboreal felid. However, margays travel and hunt regularly on the ground (Konecny 1989, Sunquist and Sunquist 2002), and we trapped all margays in our study on the ground (Caso et al. 2005). In addition, Ruell and Crooks (2007; Table 1) had reasonable success with bobcats at the same height as our snares (0.6 m). Although elevated hair snares may increase margay detection, gray foxes climb well and would not be precluded from marking snares in trees. The small area in the California study relative to range size and low density of mountain lions likely contributed to poor success of hair snares for this species.

A third alternative to explain poor felid detection is differential success in detecting canid and felid hair. Quantitative or qualitative differences in DNA between canid and felid hair follicles may lead to variation in the ability to identify species. For example, Ruell and Crooks (2007) had low genotyping success with felid hair and suggested it may be due to its fine structure and lower amounts of DNA.

As opposed to hair-snare studies, scent-station surveys have successfully detected or monitored bobcat population trends in areas within gray fox range (Brady 1979, Knowlton and Tzilkowski 1979, Morrison et al. 1979, Chamberlain et al. 1999). In addition, Harrison (1997) showed that several types of chemical attractants used with scent stations were visited, albeit at low rates (7.6% visitation overall), by ocelots, margays, and bobcats in Costa Rica. The scent-station design utilizes track identification for detection and consequently is not dependent on an animal's face-marking behavior. It is therefore possible to detect species that may have approached a station and turned away. Conversely, with the hair-snare design, visitation at a given station is only recorded by hair left on the pad.

One could redesign the hair-snare station to prevent gray fox marking. As alluded to previously, raising the height of the station above the cheek level of gray fox may be ineffective due to the species' ability to climb (Neale and Sacks 2001) unless a pole is used to mount the hair snare. In captive studies, hair snares mounted on poles 80 cm aboveground prevented gray fox marking while allowing mountain lions to mark (P. Beier, Northern Arizona University, personal communication). However, mountain lions ignored these elevated hair-snare stations in limited field tests. Ruell and Crooks (2007) developed a modified design to sample felids and canids that involved a 61-cm board with carpet nailed to the top surface. An alternative would be to change the lure. Foxes, however, are motivated by olfactory stimuli (Chamberlain et al. 1999) and will presumably investigate any novel scent in their surroundings. The presence of a visual attractant may not be relevant due to the apparent refusal of felids to face-rub sites previously marked by gray fox.

MANAGEMENT IMPLICATIONS

We caution researchers planning felid hair-snare surveys in areas inhabited by gray fox to carefully consider implications of this body of literature. Nevertheless, hair-snare protocols utilizing olfactory lures (e.g., Cat Call) and a visual aid are sufficient in determining felid presence in areas outside the range of gray fox or in areas of low gray fox density. We recommend a modified scent-station technique for bobcats (Chamberlain et al. 1999) or track surveys for large felids (e.g., mountain lions) to detect large changes in population trends (Smallwood and Fitzhugh 1995, Beier and Cunningham 1996, Choate et al. 2006) in areas of sympatry with gray fox. If project objectives include population estimation and individual identification, scat sampling may be more effective for felids (Ruell and Crooks 2007).

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