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Use of Remote Cameras to Monitor the Potential Prevalence of Sarcoptic Mange in Southern Texas, USA

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ABSTRACT: Sarcoptic mange, caused by the mite *Sarcoptes scabiei*, is a common, highly contagious skin disease that has been reported from more than 100 species of mammals, including humans. Our objectives were to 1) determine the prevalence of sarcoptic mange within mammals from southern Texas, and 2) determine the efficacy of using remote cameras to estimate mange prevalence. We collected remote camera photographs from a 64-km^2 area and blood and skin scrapings from 166 mammals representing 12 species in southern Texas, US during 2012–13. Only 16% of the 344,395 photograph series were of animals with an appearance consistent with sarcoptic mange and only individuals of four species: 16/25 feral hogs (*Sus scrofa*), 13/28 white-tailed deer (*Odocoileus virginianus*), 18/25 coyotes (*Canis latrans*), and 1/5 nilgai (*Boselaphus tragocamelus*) displayed alopecia, seborrhea, and crusted lesions that were consistent with mange. However, only feral hogs, coyotes, and white-tailed deer had mites present within skin scrapings. Two photographs of each collected mammal that displayed characteristics consistent with mange (n=83 animals; 166 photographs) were reviewed in a blind trial by a veterinarian experienced with cases of mange. The veterinarian correctly identified 18 and 97 animals from photographs as positive and negative for mange, respectively, with 19, 9, and 23 animals from photographs being false positive, false negative, and inconclusive, respectively. Moderate to severe cases of mange were readily identifiable via photographs; however, mild cases and summer coats often were misdiagnosed, making the technique of debatable use.

Key words: Mammals, photographs, prevalence, *Sarcoptes scabiei*, sarcoptic mange.

Sarcoptic mange is a common, highly contagious skin disease of mammals that is caused by the mite *Sarcoptes scabiei*. Development of the mite is rapid. Fertilized adult females burrow into the epithelium of their hosts and lay three to four eggs/d (Bornstein et al. 2001). Hatching of the eggs occurs within 3 d and the subsequent larvae molt four times to reach adulthood in approximately 2 wk (Davis and Moon 1990). After each molt the nymphs continue to burrow in the epithelium or move on the skin surface of their host.

Clinical signs of acute sarcoptic mange include intense pruritus, seborrhea, crusted lesions, alopecia (sometimes covering the entire body), thickening of the skin, listlessness, emaciation, and death (Sweatman 1971). Secondary bacterial and fungal infections are common because of excessive scratching of the infected areas, often resulting in open wounds (Trainer and Hale 1969). Many of the above signs are difficult to detect visually because a thick fur coat covers the lesions and alopecia is observed in latter stages of infestation. Lesions usually begin on the elbows, hocks, and base of tail and spread proximally and anteriorly (Morner 1981).

Sarcoptes scabiei has been reported from more than 100 species of mammals including humans (Bornstein et al. 2001), but sarcoptic mange has been most notable in canid species (Pence et al. 1983; Pence and Windberg 1994). Prevalence of sarcoptic mange in North American canids has ranged from 11% to >80% during epizootic peaks (Pence and Windberg 1994). High densities of social animals are at greatest risk of exposure to *S. scabiei*. Severe mange can result in about 80% mortality, which can devastate local wildlife populations, and is especially concerning when endangered mammals are at risk. Transmission of *S. scabiei* among wildlife occurs both by direct and indirect contact (Bornstein et al. 2001). Mites can occur on hosts in densities of hundreds to thousands

per square centimeter (Arlian et al. 1989). In addition, mites can survive in the environment without a host for weeks if relative humidity is 50–97% and temperatures are 15–25 C (Arlian et al. 1984). We hypothesized that remote cameras can be used to monitor wildlife populations for mange outbreaks; however, the concept must be tested to determine the method's feasibility. Our objectives were to 1) determine the prevalence of sarcoptic mange within mammals from southern Texas, US, and 2) determine the efficacy of using remote cameras to estimate mange prevalence.

The study was conducted on a 10,984-ha ranch of the East Foundation located immediately west of Port Mansfield, Texas (26°55′N, 97°42′E). The area is characterized as a grassland habitat intermixed with mesquite (*Prosopis glandulosa*) and live oak (*Quercus virginiana*) mottes, with an average annual precipitation of 51 cm. The property is mainly used for cattle production and wildlife conservation.

Twenty-five Reconyx® remote cameras (Holmen, Wisconsin, USA) were evenly placed at 2-km intervals in a 5×5 grid pattern, such that the camera grid covered the entire property inclusive of a 1-km surrounding perimeter. Bait was not used to lure animals to cameras. Photographs of animals passing near the cameras were collected by the camera default setting (i.e., a series of three photographs taken at 1-s intervals with a 20-s delay between series) from October 2012 to September 2013. Photographed animals were recorded for species and potential sarcoptic mange; prevalence of mange from photographs was calculated as the number of series of mange-suspected animals of a species divided by the number of series for that species. Mammal species that were potential mange reservoirs were either trapped or collected. Rodents were trapped via Sherman® live traps (H. B. Sherman, Inc., Tallahassee, Florida, USA); medium-sized animals such as raccoons (*Procyon lotor*) were trapped via Havahart® traps (Lititz, Pennsylvania, USA); and coyotes (*Canis latrans*), feral hogs (*Sus scrofa*), and javelinas (*Tayassu tajacu*) were collected via rifle gunshot. Samples from white-tailed deer (*Odocoileus virginianus*) and nilgai (*Boselaphus tragocamelus*) were collected in conjunction with a companion study. Samples from bobcats (*Lynx rufus*) were opportunistically collected as road-killed specimens. Photographs of each collected animal were taken from cranial, caudal, dorsal, and ventral views to document the extent of physical signs of mange. Quality of skin lesions was categorized as either absent, mild, moderate, or severe for mange. Skin scrapings as outlined by Bornstein and Zakrisson (1993) were analyzed by light microscopy to identify mite species. Skin scrapings from the elbow, hocks, base of tail, base of ears, and caudomedial aspect of the left thigh were collected from each animal. Additional scrapings were taken from areas of alopecia. Whole-blood samples were taken from each animal for serum collection. A commercial indirect enzyme-linked immunosorbent assay (*Sarcoptes*-ELISA dog and pig, AFOSA GmbH, Dahlewitz, Germany) was used according to the manufacturer's instructions to detect anti-*Sarcoptes* antibodies in serum samples. Product specifications indicated sensitivity and specificity of 92% and 94%, respectively, in domestic dogs, and 94% and 97%, respectively, in domestic pigs. Two photographs of each collected animal were reviewed in a blind trial by a veterinarian experienced with cases of mange. Photographs were categorized as either healthy animals or *Sarcoptes* infested. We assumed that if an experienced individual had difficulty correctly identifying mite-infested animals, then the concept of using remote cameras to determine prevalence of mange would not be valid.

A general linear model analysis was used to test for differences in antibody titers between mite-positive and mite-negative animals. We used chi-square tests to determine if the actual prevalence of mange occurred in proportion to that classified from photographs and compared the accuracy and precision of the veterinarian's classification of mange-infected species with the actual prevalence. Significance level was set at $P \leq 0.05$ in all tests.

TABLE 1. Prevalence of physical signs of mange, mites collected from skin scrapings, and titers to *Sarcoptes scabiei* in selected mammal species were determined during a coyote (*Canis latrans*) epizootic of mange in southern Texas, USA during 2012–13. Titers were determined using mammalian sera by *Sarcoptes*-ELISA dog and pig tests.

Species	Prevalence				Titers[a]				
	Physical signs		Mite presence		Physical signs	Mean	Median	Mode	Range
Rodents									
Hispid pocket mouse (*Chaetodipus hispidus*)	0/10	0%	0/10	0%	None	0	0	0	0
Silky pocket mouse (*Perognathus flavus*)	0/10	0%	0/10	0%	None	0	0	0	0
Cotton rat (*Sigmodon hispidus*)	0/20	0%	0/20	0%	None	0	0	0	0
Lagomorphs									
Cottontail rabbits (*Sylvilagus floridanus*)	0/5	0%	0/5	0%	None	0	0	0	0
Black-tailed jackrabbits (*Lepus californicus*)	0/5	0%	0/5	0%	None	0	0	0	0
Ungulates									
Feral hog (*Sus scrofa*)	16/25	64%	14/25	56%	Alopecia/seborrhea	1:106	1:64	1:256	0–1:512
Javelina (*Tayassu tajacu*)	0/10	0%	0/10	0%	None	0	0	0	0
White-tailed deer (*Odocoileus virginianus*)	13/28	46%	9/28	32%	Alopecia	1:22	1:64	1:64	1:8–1:64
Nilgai (*Boselaphus tragocamelus*)	1/5	20%	0/5	0%	Alopecia	0	0	0	0
Predators									
Coyote	18/25	72%	14/25	56%	Alopecia/seborrhea Crusted lesions/ thickened skin	1:143	1:64	1:64	1:8–1:1,024
Bobcat (*Lynx rufus*)	0/3	0%	0/3	0%	None	1:8	1:4	0	0–1:16
Raccoon (*Procyon lotor*)	0/20	0%	0/20	0%	Alopecia	1:12	1:16	1:16	1:4–1:16
Totals[b]	48/166	29%	37/166	22%		1:54	1:6	0	0–1:1,024

[a] 0 titer = no appreciable amount of antibodies were detected.

[b] Forty-eight of 166 (29%) animals exhibited titers to mange (range=1:4–1,024): two bobcats, three raccoons, nine white-tailed deer, 16 feral hogs, and 18 coyotes.

Remote cameras took 344,395 photograph series, of which 53% were of cattle and 17% were of miscellaneous subjects (e.g., vegetation, birds, indistinguishable subjects, and species with frequencies <1%). Of the 108,767 remaining photograph series, 9, 7, 7, 5, 3, and 1% were of white-tailed deer, feral hogs, coyotes, raccoons, nilgai, and javelina, respectively. The total percentage of photographs is >100% because several photographs consisted of multiple species. The number of photographed animals that appeared to have mange was not proportional (χ^2=20,422, df=5, P<0.0001) to the number of photograph series of each species, with more coyotes and fewer raccoons appearing to have signs of mange than expected. However, the estimated prevalence of mange for each species exceeded the actual prevalence. The estimated prevalence from photographs and the actual prevalence of mange was 48% and 32%, respectively, for white-tailed deer; 65% and

TABLE 2. Review of photographs in a blind study by a veterinarian experienced with cases of mange of mammalian species with potential sarcoptic mange to determine if photographs are a sufficient method to diagnose mange. Mammalian wildlife species were collected from southern Texas, USA during 2012–13, a time during a coyote (*Canis latrans*) mange epizootic. Photographs were assessed as 1) positive if both photographs were determined as mange cases when sarcoptic mites were present; 2) negative if both photographs determined that physical signs of mange were absent when mites were absent; 3) false positive if both photographs were determined as mange cases when sarcoptic mites were absent; and 4) false negative if both photographs determined that physical signs of mange were absent when sarcoptic mites were present. Results were inconclusively positive if one photograph was deemed a mange case and the other photo was deemed negative when in actuality the animal was positive for mites. Results were inconclusively negative if one photograph was deemed a mange case and the other photo was deemed negative when in actuality the animal was negative for mites.

Species[a]	*n*	Positive	Negative	False positive	False negative	Inconclusive	
						Positive	Negative
Rodents	40	0	40	0	0	0	0
Lagomorphs	10	0	10	0	0	0	0
White-tailed deer (*Odocoileus virginianus*)	28	4	15	2	4	1	2
Feral hogs (*Sus scrofa*)	25	6	2	5	3	5	4
Javelina (*Tayassu tajacu*)	10	0	8	0	0	0	2
Nilgai (*Boselaphus tragocamelus*)	5	0	3	1	0	0	1
Coyote	25	8	5	6	2	4	0
Raccoon (*Procyon lotor*)	20	0	11	5	0	0	4
Bobcat (*Lynx rufus*)	3	0	3	0	0	0	0
Overall	166	18	97	19	9	10	13

[a] Rodents collected were hispid pocket mice (*Chaetodipus hispidus*; *n*=10), silky pocket mice (*Perognathus flavus*; *n*=10), and hispid cotton rats (*Sigmodon hispidus*; *n*=20). Lagomorphs collected were cottontail rabbits (*Sylvilagus floridanus*; *n*=5) and black-tailed jackrabbits (*Lepus californicus*; *n*=5). Remaining species are already identified.

56%, respectively, for feral hogs; 75% and 56%, respectively, for coyotes; 20% and 0%, respectively, for raccoons and nilgai; and 10% and 0%, respectively, for javelina.

Only feral hogs (56%), white-tailed deer (32%), and coyotes (56%) were infested with *S. scabiei* (Table 1). Not all animals that had mites exhibited physical signs of mange. Titers to *S. scabiei* ranged from 0 to 1:1,024 (Table 1), with titers from mite-positive animals higher (mean=1:212; range=0–1:1,024; t-statistic value=25.1, df=164, $P<0.001$) than from animals that were negative for mites (mean=1:8; range=0–1:64). Coyotes exhibited alopecia, seborrhea, crusted and seeping lesions, apparent secondary infection, and thickening of the skin. Feral hogs and white-tailed deer were mildly to moderately affected with localized alopecia and seborrhea.

The veterinarian correctly identified 69% of the photographs from collected specimens as either positive or negative for mites, which was greater than expected (χ^2=28.7, df=1, $P<0.000$), with 65% of the χ^2 value being attributed to correctly identifying mite-positive and mite-negative animals; 17% of animals were misidentified, and 14% were inconclusive (Table 2). In addition, the precision of the veterinarian was greater than expected (χ^2=85.3, df=1, $P<0.000$), with 92% of the pairs of photographs classified similarly.

The use of remote cameras to determine the onset of mange epizootics or the prevalence of mange is no better, but no worse, than surveying animals in the field. Inaccuracy of identifying mange via photographs was mainly due to difficulty in differentiating mild cases of mange from seasonal changes in fur coats. Cases of mange did not become apparent until the parasitic infestation became moderate in appearance (Pence et al. 1983); therefore, knowledge of an onset of a mange

epizootic would be delayed if relying solely on cameras. Such time delays could prove detrimental if proactive actions are necessary to aid threatened and endangered species. Avoiding periods during seasonal molting may reduce this problem; however, molting periods lengthen considerably as one approaches the equator (Halls 1978). Additionally, overall prevalence of mange in wild mammals was overestimated twofold when only photographs were used.

The species infested with *S. scabiei* from southern Texas were not surprising. Mange is noted in canids (Pence and Windberg 1994), wild boar (Haas et al. 2015), and species of cervidae (Bornstein et al. 2001), but sarcoptic mange is not commonly reported in white-tailed deer. We demonstrate that white-tailed deer do become infested with *S. scabiei*; however, all cases were localized and mild. Sarcoptic mange in deer may be incidental when wildlife densities and mange prevalence become regionally high. Transmission between some hosts is possible (Bornstein et al. 1995). Also, sarcoptic mange in deer normally may be asymptomatic, and go unnoticed. Javelina are known hosts of *S. scabiei*; however, javelina in our study were not infested. Perhaps this is due to our small sample size of javelina, or perhaps javelina avoided areas frequented by feral hogs (Ilse and Hellgren 1995), reducing their exposure to *S. scabiei*.

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