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Seroprevalence of *Sarcoptes scabiei* in Free-ranging Black Bears (*Ursus americanus*) in Eastern North Carolina, USA

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ABSTRACT: Recent sarcoptic mange epizootics have affected free-ranging black bears (*Ursus americanus*) in the northeastern US, but not in North Carolina. To determine whether black bears in eastern North Carolina have exposure to *Sarcoptes scabiei*, serum samples from hunter-harvested black bears (n=45) were collected and evaluated for antibodies using a commercial enzyme-linked immunosorbent assay previously validated in black bears. No dermal lesions consistent with sarcoptic mange were identified in the sampled bears. The seroprevalence among these asymptomatic bears was 18%, with no significant difference between sexes or association with age. This suggests that exposure to *Sarcoptes scabiei* occurs within the population, and highlights the importance of serosurveys in regions without a history of clinical mange.

Key words: Black bear, *Sarcoptes scabiei*, sarcoptic mange, serology, ursid, *Ursus americanus*.

Sarcoptes scabiei, a widely distributed and highly contagious mite, infests more than 100 species of domestic and wild mammals (Pence and Ueckermann 2002). A clinical case of *S. scabiei* infestation in a black bear (*Ursus americanus*) was described in 1987 (Schmitt et al. 1987). In recent years, epizootics of sarcoptic mange in black bears showing severe clinical signs have occurred in Pennsylvania, New York, and Virginia (Peltier 2016). The epidemiology of sarcoptic mange in black bears is complex, as evidenced by investigations into the current epizootic in Pennsylvania, which found multiple genetic variants of *S. scabiei* in the affected population (Peltier 2016). In black bears, there is no apparent association between clinical *S. scabiei* infestation and other infectious agents such as canine distemper virus, canine parvovirus, canine adenovirus-1, *Toxoplasma gondii*, and *Trichinella* (Niedringhaus et al. 2019c).

Skin scrapes are sensitive for detecting *S. scabiei* in dogs and bears with active lesions, but much less effective for detecting mites in mild or subclinical cases (Walton and Currie 2007). Enzyme-linked immunosorbent assays (ELISAs) have been used successfully to detect antibodies to *S. scabiei* in many wildlife species, including red foxes (*Vulpes vulpes*), Scandinavian wolves (*Canis lupus*), Siberian ibex (*Capra pyrenaica*), and wild boar (*Sus scrofa*; Bornstein et al. 2006; Fuchs et al. 2016; Ráez-Bravo et al. 2016; Haas et al. 2018). A commercial ELISA originally developed for use in domestic dogs has been used to detect *S. scabiei* antibodies in symptomatic black bears (Peltier et al. 2018) and was recently validated for use in black bears, with a sensitivity and specificity of 95.6% and 96.6.%, respectively (Niedringhaus et al. 2020).

Although there have been no recent confirmed cases of sarcoptic mange in North Carolina black bears, there have been rare anecdotal reports of bears with mild to moderate alopecia and crusting without any confirmatory testing. Additionally, the geographical range of sarcoptic mange in black bears has been expanding from the northeastern US toward North Carolina within the past two decades (Niedringhaus et al. 2019b). Our objective was to determine the prevalence of antibodies to *S. scabiei* in asymptomatic free-ranging black bears in eastern North Carolina, using the validated commercial ELISA for *S. scabiei*.

We collected blood from 66 hunter-harvested black bears in Hyde and Tyrell counties of North Carolina during the 2018 November black bear hunting season. We sampled blood via femoral venipuncture,

cardiocentesis, from that dripping from the oronasal cavity, or pooling in the gunshot wound. Blood was stored in sealed glass tubes at 4 C for up to 72 h to allow for natural serum separation, and the serum was then pipetted into cryovials. Serum was stored at –20 C until analysis. We performed an external physical examination on all bears, recording sex and any dermal lesions. To determine age of the black bear we removed an upper premolar, which was sent to Matson's Laboratory (Manhattan, Montana, USA) for analysis (Willey 1974). Sera from 19 bears were excluded because of extreme hemolysis that rendered the serum of poor quality for ELISA. Two additional bears were excluded from analyses due to lack of age data.

We analyzed 45 bear serum samples with *Sarcoptes*-Dog ELISA (AFOSA, Blankenfelde-Mahlow, Germany) per the manufacturer's instructions. Serum from a black bear previously confirmed to have sarcoptic mange based on the presence and identification of *S. scabiei* mites, and serum from a black bear cub born to a seronegative sow and collected prior to emergence from the den were obtained from the University of Georgia Southeastern Cooperative Wildlife Disease Study and used as positive and negative controls, respectively. The control samples had been collected into serum separator tubes, centrifuged, and stored at –20 C until analysis (Peltier 2016). We analyzed canine sera positive and negative for *S. scabiei* provided by the manufacturer of the commercial ELISA test to verify that the assay was working within expected parameters. The corrected optical density, test result values, and test result value interpretations were performed as described by Niedringhaus et al. (2020). A two-tailed Fisher's exact test was performed to compare seroprevalence between male and female bears. A Mann-Whitney *U*-test was performed with statistical software (RStudio, version 1.2.1335, R Development Core Team 2020) to compare the ages of positive and negative bears.

Clinical signs of sarcoptic mange in black bears in Pennsylvania are diffuse alopecia with hyperkeratotic, lichenified, and crusted skin

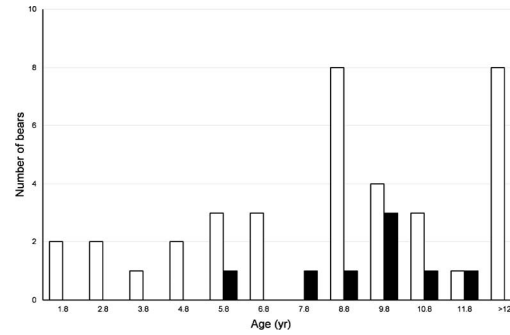

FIGURE 1. The age distribution of black bears (*Ursus americanus*), harvested in eastern North Carolina, USA during the November 2018 hunting season, which were seropositive (black bars) and seronegative (white bars) for *Sarcoptes scabiei*.

(Peltier et al. 2018; Niedringhaus et al. 2019a). This severe presentation is consistent with the crusting form of sarcoptic mange described in humans (Walton and Currie 2007). In our study, no skin lesions consistent with sarcoptic mange were identified on the sampled black bears.

Of the 45 serum samples analyzed from bears in our study, eight were positive (18%) and 37 (82%) were negative. There was no significant difference in seropositivity between females (13%; 2/15) and males (20%; 6/30) in this population (P=0.699), similar to black bears symptomatic with sarcoptic mange in Pennsylvania (Peltier 2016). The median age of sampled black bears was 8.8 yr (1.8–18.8 yr). Age was not significantly associated with seropositivity status (P=0.676), although all positive bears were between five and 12 yr old (Fig. 1). In one survey of Pennsylvania black bears, adults had a higher seroprevalence than yearlings, but the difference was not significant (Peltier et al. 2018). In our study population, a low proportion of yearlings (n=2) might have lessened detection of any differences in seroprevalence between ages.

Seropositive individuals in this study might have had subclinical infestations, which has been described in Norwegian red foxes, in pigs (*Sus scrofa*), and in water buffalo (*Bubalus bubalis*; Davidson et al. 2008; Dimri et al. 2008, 2014). In humans, the ordinary (noncrusted) form of sarcoptic mange is more

common and can be subclinical (Walton and Currie 2007). Dysregulation of the immune system is a key factor in the development of crusted scabies in humans (Bhat et al. 2017). Variations in host response and the genetic diversity of *S. scabiei* variants, possibly impacting virulence, could contribute to regional differences in the prevalence of clinical sarcoptic mange in bears (Peltier et al. 2017). Weather, climate, seasonality, and sample quality (body fluid vs. serum) might also contribute to differences in clinical presentation and seroprevalence.

Seropositive individuals in our study without clinical signs might also represent an early infestation. Clinical dermatologic signs and antibody response in humans might not develop for at least 4 wk following arrival of the mites, because *S. scabiei* mites have immunomodulatory effects that slow local and systemic reactions to infestation (Bhat et al. 2017).

Prior infestation and clearance of *S. scabiei* also might produce seropositive individuals without clinical signs. Based on antibody persistence studies in clinically affected *S. scabiei*-infested black bears, antibodies are expected to be detectable for 4–14 wk after successful resolution of clinical signs post-treatment (Niedringhaus et al. 2020).

It is possible that the seropositive animals in this study could be false positives, although cross reactions of the assay with other common black bear ectoparasites, such as *Ursicoptes americanus*, have not been demonstrated. Although there is no historical evidence of *Ursicoptes americanus* infestations in North Carolina, exposure to this mite could have falsely elevated the seroprevalence detected with the ELISA in our study's population.

The seroprevalence in this population of black bears in eastern North Carolina was higher than the reported seroprevalence in both regions of low and high mange occurrence (0% and 6.7%, respectively) in Pennsylvania (Niedringhaus et al. 2020). This highlights the importance of screening populations without a history of clinical mange, to appreciate their exposure to this widespread parasite. Further *S. scabiei* serosurveys of black bears in other regions of both low and high mange occurrence could reveal insights into the factors that contribute to clinical disease in free-ranging populations.

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