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The Occurrence and Prevalence of Giraffe Skin Disease in Protected Areas of Northern Tanzania

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ABSTRACT: Giraffe skin disease (GSD) is a disorder of undetermined etiology that causes lesions on the forelimbs of Masai giraffe (*Giraffa camelopardalis tippelskirchi*). We estimated occurrence and prevalence of GSD in six wildlife conservation areas of Tanzania. The disjunct spatial pattern of occurrence implies that environmental factors may influence GSD.

The range of the giraffe (*Giraffa camelopardalis*) once covered most savanna ecosystems of Africa but is now discontinuous and reduced as a result of rinderpest pandemics, poaching, human settlement, deforestation, and habitat loss (Dagg 2014). The remaining isolated populations are generally declining (Dagg 2014) and increasingly vulnerable to stochastic factors, such as diseases (Caro 2008).

Giraffe skin disease (GSD) is a disorder of the skin that is grossly characterized by proliferative, crusty lesions on the posterior forelimbs of adult and subadult Masai giraffe, (*Giraffa camelopardalis tippelskirchi*) the only subspecies in Tanzania (Fig. 1; Epaphras et al. 2012). Tissue samples from 12 infected animals were used to identify potential causative agents, particularly an unidentified larval nematode parasite, fungi, and bacteria (Mpanduji et al. 2011), but these speculations have not been confirmed.

First reported in 2000 in Ruaha National Park (RNP) in central Tanzania, GSD has spread, with an estimated 92% prevalence among RNP adults in 2009 (Epaphras et al. 2012) and has been anecdotally observed in Tarangire National Park (TNP) in northern Tanzania >300 km away (D.E.L. unpubl. data). Site-specific data on the occurrence (presence or absence) and prevalence (percent affected) of GSD from areas outside of RNP are lacking. Such data are important for conservation of this declining species, as observations suggest that GSD could have significant effects on giraffe population viability. Some severely affected giraffe exhibit a stiffness or lameness of gait (Epaphras et al. 2012), possibly making them more vulnerable to predation or poaching. The disease also may increase vulnerability to secondary infections at the site of lesions, systemic infections, or other opportunistic infections.

Quantifying regional prevalence of GSD will help identify hot spots and possibly disease-free refugia, as well as potential environmental risk factors and transmission corridors. We estimated the occurrence and prevalence of GSD in six sites in northern Tanzania known to support giraffe populations: Serengeti National Park (SNP), Ngorongoro Conservation Area (NCA), Lake Manyara National Park (LMNP), Manyara Ranch Conservancy (MRC), Arusha National Park (ANP), and TNP (Fig. 2). These data are essential for establishing a baseline for future studies of incidence (rate of spread), for assessing the risk to giraffe populations from this emerging disease, and for formulating effective mitigation strategies if necessary.

From March through June of 2014, we surveyed for GSD by driving on roads within the six protected areas. Surveys took place during the wet season, when prevalence was reported to be highest in RNP (Mpanduji et al. 2011). We conducted two replicate surveys in TNP, LMNP, and MRC, and one survey each in SNP, ANP, and NCA. The disease is much more prevalent in adults in RNP, relative to subadults and calves (Epaphras et al. 2012), so we restricted our observations to adult animals. For each adult giraffe encountered, we noted sex and, if the posterior side of the front legs were observable, whether

FIGURE 1. Photographs of giraffe skin disease lesions on the posterior forelimbs of adult Masai giraffe (*Giraffa camelopardalis tippelskirchi*) in Tarangire National Park, Tanzania, in 2014. The top is a moderate case; the bottom is a severe case.

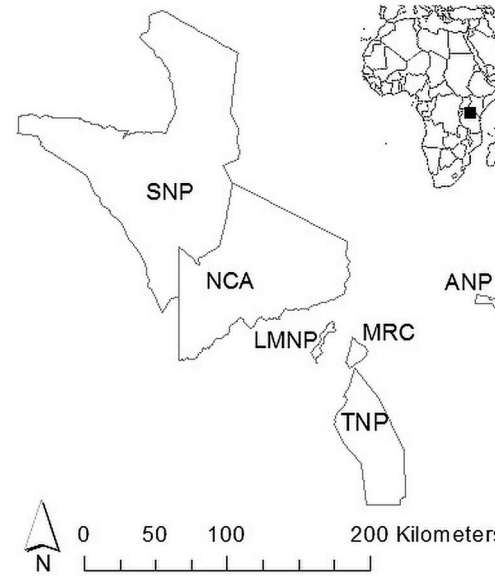

FIGURE 2. Six wildlife conservation area sites in northern Tanzania where we assessed the occurrence and prevalence of giraffe skin disease in adult, free-ranging Masai giraffe (*Giraffa camelopardalis tippelskirchi*) during 2014. The black square within inset map of Africa shows the study region. SNP=Serengeti National Park; NCA=Ngorongoro Conservation Area; LMNP=Lake Manyara National Park; MRC=Manyara Ranch Conservancy; TNP=Tarangire National Park; ANP=Arusha National Park. Location of labels for SNP, NCA, and TNP indicate approximate sampling locations within the site boundaries.

GSD symptoms were visible (positive or negative). Occurrence was denoted as presence or absence of GSD within each of the six conservation areas, and prevalence was measured as the number of animals visually determined to be affected, divided by the total number of animals for which the posterior side of the front legs was visible.

We recorded adult giraffe with GSD in TNP (61%, n=159), SNP (23%, n=53), and MRC (10%, n=145). We observed no giraffe with GSD symptoms in LMNP (n=100), ANP (n=13), or NCA (n=24). Our data do not support a spatial pattern of increasing prevalence from south to north, which we had expected, given that the disease was first reported in central Tanzania south of the conservation areas we surveyed. Disease was detected in our most southerly and most northerly areas but not in three of the areas in between. Ruaha National Park, where GSD was first detected, is >300 km south of TNP and has 92% adult GSD prevalence (Epaphras et al. 2012). No data were available for the areas between RNP and TNP. We examined whether soil type, precipitation, or vegetation communities might explain our observed spatial pattern by assigning site-specific values for each site (including RNP) using maps (East African Meteorological Department 1961; Food and Agriculture Organization of

the United Nations 2003, 2012; van Breugel et al. 2015) and regressing prevalence against categorical (vegetation and soil type) or continuous (precipitation) explanatory variables using the R statistical language (R Development Core Team 2013). Prevalence at the seven sites was not significantly correlated with mean annual precipitation (t=–0.75, P=0.49). Vegetation communities were not similar among sites that had similar prevalence rates (statistics not possible). The disease was less prevalent or absent on volcanic soils but more prevalent on granitic soils (t=2.79, P=0.053).

The discontinuous spatial distribution of GSD prevalence was best explained by soil type. If parasites, such as nematodes, are involved in the pathogenesis of GSD, differences in soil pH, cation exchange capacity, or salinity may influence ground-dwelling life stages. Alternatively, soil characteristics may impact the nutritional status of giraffes through vegetation quality, thereby altering their susceptibility to GSD. The presence of potential vectors, such as biting flies, may also vary in different environmental conditions or in the presence of various host species. We have observed a few cases of apparent Kikoboga ear disease (Lyaruu 2010), papillomavirus-associated lesions (van Dyk et al. 2011), and mange in TNP, MRC, and LMNP, but these skin pathologies are rare (<5% prevalence), and we believe they likely do not have population-level impacts. An individual-based demographic study of giraffe is underway in TNP and MRC, and data from a similar study in SNP will provide estimates of GSD-related mortality and the fine-scale spatial pattern of occurrence and prevalence across a gradient of soil types.

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