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Wild pigs as sentinels for hard ticks: A case study from south-central Florida

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ABSTRACT

As a result of shifts in the habitable range of ticks due to climate change and the ongoing threat of exotic tick species introductions, efficient surveillance tools for these pests and disease vectors are needed. Wild pigs are habitat generalists, distributed throughout most of the United States, and often hunted recreationally or removed as part of management programs, making them potentially useful sentinel hosts for ticks. We compared ticks collected from captured wild pigs and standard tick dragging methods on a south-central Florida cattle ranch from May 2015–August 2017. Three hundred and sixteen wild pigs were surveyed, and 84 km spanning three habitat types (seminative pasture, improved pasture, and hammock) were dragged. In total, 1023 adults of four species (*Amblyomma auricularium*, *Amblyomma maculatum*, *Dermacentor variabilis*, and *Ixodes scapularis*) were collected from wild pigs, while 39 adults of three species (*A. auricularium*, *A. maculatum*, and *I. scapularis*) were collected from drags. Only one immature specimen, a nymph, was collected from a pig, while dragging collected 2808 larvae and 150 nymphs. *Amblyomma maculatum* comprised 96% of adults collected from pigs, while *A. maculatum*, *I. scapularis,* and *A. auricularium* comprised 38%, 33%, and 28% of adults collected from drags, respectively. Adults of all tick species found on drags were found on pigs, and wild pig surveillance detected adults of an additional species not found on drags. Dragging was far superior for collection of immatures but not for adults of most species found in this study. These findings suggest wild pigs could be used as a sentinel for the detection of tick species. When combined with ongoing wild pig research, hunting, or management, wild pig surveillance can provide an effective method to survey for adult tick presence of some species of interest and may assist in tracking the range expansion of some tick species.

1. Introduction

The need for proactive and efficient methods of surveillance for ticks is increasing. Climate change causes shifts in the habitable range of vectors, allowing them to expand into new regions (Dantas-Torres, 2015). In addition, over the past few decades, at least 99 exotic tick species, including known vectors of disease, have been imported to the United States or discovered at ports of entry (Keirans and Durden, 2001). As a result of the changing climate and increased trade of domestic livestock, ticks and their associated pathogens are emerging in new locations and threatening the health of humans and animals (Barré and Uilenberg, 2010). Early detection of tick range expansions and of exotic tick species introductions is critical to inform veterinary and public health response measures.

The goals of tick surveillance vary, but often include monitoring for the emergence of exotic species or assessing range, habitat use, and host use for native tick species. Methods of tick surveillance include both environmental or host surveys (Estrada-Pena et al., 2013). Environmental surveys for host-seeking ticks are wide-ranging and include cloth dragging and flagging, walking surveys, surveys of animal nests, and carbon-dioxide-baited or other attractant-baited traps (Koch and McNew, 1981; Schulze et al., 1986, 1997; Ginsberg and Ewing, 1989; Petry et al., 2010; Cohnstaedt et al., 2012; Portugal and Goddard, 2015; Mays et al., 2016). Host sampling includes surveys of humans, companion animals, domestic livestock, and wild animals trapped for research or management or harvested by hunters (Ogden et al., 2006; Rand et al., 2007; Hamer et al., 2009; Cohnstaedt et al., 2012; Hertz et al., 2017; Mertins et al., 2017).

The efficacy of all surveillance types may vary depending on tick biology, tick life stage, tick host-seeking methods, host selection, habitat type, and weather (Ginsberg and Ewing, 1989; Wilson, 1994; Schulze et al., 1997; Petry et al., 2010; Cohnstaedt et al., 2012). Drag

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method results are highly influenced by habitat type and vegetation structure, and even within habitat types, ticks are often heterogeneously distributed (Wilson et al., 1988; Dobson et al., 2011). For example, if ground vegetation prevents a drag-cloth from reaching the lower levels of vegetation or leaf litter, this may prevent collection of ticks which quest at low heights. Additionally, host-seeking tick surveillance methods are affected by both time of day and short-term environmental conditions (Wilson, 1994). In contrast, host surveillance is not as affected by vegetation structure or short-term weather variables (Wilson, 1994; Estrada-Pena et al., 2013), and sentinel animals are available to host-seeking ticks for longer periods of time than standard drag sampling. Sampling of sentinel animals may better detect ticks that are at low densities in the environment or not responsive to host-seeking tick surveillance, and has been shown to provide informative assessments of tick control efforts (Ginsberg and Ewing, 1989; Schulze et al., 1997; Hamer et al., 2009; Polito et al., 2013).

Good sentinel hosts are species which are readily observable and more likely than others to be exposed to ticks (Halliday et al., 2007). The ideal sentinel host depends on the tick species and life stage of interest. Tick attraction to and ability to utilize a sentinel host are necessary factors for any sentinel tick surveillance. In the case of detection of adults of many tick species, an ideal sentinel would be a vertebrate host that has a medium to large body size (Esser et al., 2016), is regularly handled in large numbers, and utilizes diverse habitats over a large but relatively stable home range. Surveys of domestic animals such as dogs (*Canis familiaris* L.) and cattle (*Bos taurus* L., *Bos indicus* L., and their crosses) are often utilized to assess tick distribution, tick-borne disease risk, and tick control methods as they fit many of these criteria (Barnard, 1981; Johnson et al., 2004; Hamer et al., 2009; Polito et al., 2013; Pompo et al., 2016). However, differing vector control practices, such as the use of acaricides, complicate comparability of domestic animal surveys, may protect animals from attaching ticks, and interfere with the aim of tick species detection (Hamer et al., 2009; Pompo et al., 2016). Large-bodied wildlife, particularly game or pest species which are harvested regularly, can provide a useful alternative. Examination of white-tailed deer (*Odocoileus virginianus* Zimmermann) and other game at hunter-check stations has proven valuable for assessing tick distribution over large areas and understanding the role large-bodied wildlife play in the ecology of ticks (Allan et al., 2001; Cortinas and Kitron, 2006; Yabsley et al., 2009; Hertz et al., 2017).

Wild pigs (*Sus scrofa* L.) are a large-bodied, non-native, invasive mammal introduced to the mainland United States by European explorers in the 16th century, with multiple reintroductions occurring since (Mayer and Brisbin, 1991). Wild pigs consist of released or escaped domestic swine, Eurasian wild boar, and their hybrids. Over the past few decades, the distribution of wild pigs in the United States has expanded dramatically (Gipson et al., 1998; Bevins et al., 2014). Wild pigs have now been reported in most states, and share space and resources with other wildlife, domestic livestock, and humans. Their wide geographical range and ability to thrive in multiple habitat types, combined with ongoing and widespread removal efforts as well as recreational hunting across the United States, suggest that wild pigs are a potentially useful and easily accessible sentinel species.

Wild pigs in the United States typically have home ranges of multiple square kilometers (Kurz and Marchinton, 1972; Adkins and Harveson, 2007; Mersinger and Silvy, 2007; Friebel and Jodice, 2009) and utilize a variety of habitats (Wood and Brenneman, 1980; Singer et al., 1981; Barrett, 1982; Baber and Coblentz, 1986). Wild pigs have previously been found to host multiple native and non-native tick species with differing habitat preferences, including important pests of wildlife and many well-known vectors of livestock and human disease (Table 1). Surveillance of wild pigs detected the geographic expansion of *Dermacentor variabilis* in Texas (Sanders et al., 2013). However, unlike other sympatric wildlife, wild pigs were not found to be important hosts of the economically important cattle fever ticks (*Rhipicephalus (Boophilus) annulatus* (Say) and *Rhipicephalus (Boophilus) microplus* (Canestrini)) near the Mexico/Texas border (Corn et al., 2016). Currently, information is lacking on how active tick surveillance using wild pigs in the United States compares to dragging methods. Surveillance of wild pigs may provide a way to sample greater areas in environments that are not conducive to drag methods, to detect certain species which do not respond to dragging, and to detect non-native tick species before they are at numbers sufficient to detect through drags.

The objectives of this study were to compare the ability of cloth dragging and wild pig sampling to detect the presence, abundance, and life stages of tick species on a working beef cattle ranch in south-central Florida. We expected that wild pig samples would predominantly capture adults, as suggested by previous studies (Greiner et al., 1984; Hertz et al., 2017). Immature stages of many tick species found in south-central Florida, such as *Amblyomma maculatum* Koch, *Dermacentor variabilis* (Say), and *Ixodes scapularis* Say, commonly parasitize small and medium vertebrate hosts (Bishopp and Trembley, 1945; Clymer et al., 1970; Keirans et al., 1996; Kollars et al., 2000; Teel et al., 2010). Thus, we expected that drag sampling would produce higher numbers of immatures than sampling wild pigs. We hypothesized that sampling wild pigs would detect greater numbers and higher species richness of adults than dragging since wild pigs spend time in multiple, diverse microhabitats suitable for different tick species.

2. Materials and methods

2.1. Study site

The MacArthur Agro-ecology Research Center, a division of Archbold Biological Station, is located at Buck Island Ranch in Lake Placid, Florida (Fig. 1) (Swain et al., 2013). At the site, around 3000 cattle utilize two pasture types referred to as “improved” and “seminative.” In the mid-1900s, ranch owners plowed and planted most of the upland dry prairie portions of the ranch with exotic forage species such as Bahia grass (*Paspalum notatum*), as well as installed a well-developed system of ditches for water regulation, creating improved pastures. Seminative pastures are at lower elevations than the improved pastures and still host many native wet prairie plant species. Multiple stands of trees, regionally referred to as “hammocks,” are found on the ranch. These hammocks are closed canopy forests with moist soil, typically dominated by evergreen species such as live oak (*Quercus virginiana*) and cabbage palm (*Sabal palmetto*), with a fairly open shrub layer and sparse herb layer (U.S. Fish and Wildlife Service, 1999). Buck Island Ranch also contains two large wetland sites which together total more than 700 acres, and hundreds of smaller seasonal wetlands which are typically less than 1.5 acres in size (Swain et al., 2013; MacArthur Agro-ecology Research Center, 2014). The ranch hosts many native wildlife species such as white-tailed deer, wild turkey (*Meleagris gallopavo* L.), and Northern bobwhite (*Colinus virginianus* L.), as well as invasive species such as wild pigs (MacArthur Agro-ecology Research Center, 2014).

2.2. Host-seeking tick surveillance

Host-seeking tick surveillance was conducted from May 14, 2015 to August 29, 2017 by dragging a white, 1 m^2 corduroy or velveteen cloth along the ground and over vegetation in three habitat types: improved pastures, seminative pastures, and hammocks for up to 1000 m per drag. Tick dragging was performed during daylight hours when no dew was present on the ground. The cloth was checked for ticks every 10 m, and any ticks found were collected, kept alive on ice packs or at ambient temperature, and later the same day stored in 90% ethanol, frozen at −20 °C, or both. For each drag, data such as start and end time, global positioning system coordinates for the beginning and end of each transect, total drag distance, habitat type, and pasture name were recorded. Monthly drags were conducted in each of the three habitat types. For the first four months of the study (May–August 2015), we