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Movement patterns of nilgai antelope in South Texas: Implications for cattle fever tick management

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ABSTRACT

Wildlife, both native and introduced, can harbor and spread diseases of importance to the livestock industry. Describing movement patterns of such wildlife is essential to formulate effective disease management strategies. Nilgai antelope (*Boselaphus tragocamelus*) are a free-ranging, introduced ungulate in southern Texas known to carry cattle fever ticks (CFT, *Rhipicephalus* (*Boophilus*) *microplus*, *R.* (*B.*) *annulatus*). CFT are the vector for the etiological agent of bovine babesiosis, a lethal disease causing high mortality in susceptible *Bos taurus* populations and severely affecting the beef cattle industry. Efforts to eradicate CFT from the United States have been successful. However, a permanent quarantine area is maintained between Texas and Mexico to check its entry from infested areas of neighboring Mexico states on wildlife and stray cattle. In recent years, there has been an increase in CFT infestations outside of the permanent quarantine area in Texas. Nilgai are of interest in understanding how CFT may be spread through the landscape. Thirty nilgai of both sexes were captured and fitted with satellite radio collars in South Texas to gain information about movement patterns, response to disturbances, and movement barriers. Median annual home range sizes were highly variable in males (4665 ha, range = 571–20,809) and females (1606 ha, range = 848–29,909). Female movement patterns appeared to be seasonal with peaks during June-August; these peaks appeared to be a function of break-ups in female social groups rather than environmental conditions. Nilgai, which reportedly are sensitive to disturbance, were more likely to relocate into new areas immediately after being captured versus four other types of helicopter activities. Nilgai did not cross 1.25 m high cattle fences parallel to paved highways but did cross other fence types. Results indicate that females have a higher chance of spreading CFT through the landscape than males, but spread of CFT may be mitigated via maintenance of cattle fences running parallel with paved highways. Our results highlight the importance of documenting species-specific behavior in wildlife-livestock interfaces that can be used to develop effective disease management strategies in the United States and worldwide.

1. Introduction

Management of diseases in a wildlife-livestock interface can be difficult, especially in an environment where susceptible or host animals can move freely (Fèvre et al., 2006). The movement of livestock can be controlled with man-made barriers, but wildlife present a greater challenge in the wildlife-livestock interface. Quantifying movement patterns of wildlife improves understanding of potential spatiotemporal interactions between livestock and wildlife species (Vercauteren et al., 2007; Wyckoff et al., 2009). Additionally, documenting periods of wide-ranging movements (e.g., dispersal), potential barriers to movements (e.g., fences), and sex -specific movement behavior (e.g., mate

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search) of species involved in pathogen maintenance and transmission increases knowledge of potential risk factors associated with transmission of disease in susceptible populations (Rosatte et al., 2010; Yockney et al., 2013). Gaining such knowledge from wildlife will increase efficacy of management strategies aimed towards disease eradication in a wildlife-livestock interface (Pérez de León et al., 2012).

Bovine babesiosis is a tick-borne disease caused by the protozoan parasites of the genus *Babesia* (*B. bovis* and *B. bigemina*) with clinical manifestations of hemoglobinuria, dark red or brown-colored urine, anemia, high fever, and death (Bock et al., 2004). *B. bovis* and *B. bigemina* are known to occur in cattle in Africa, Asia, Australia, and Central and South America (de Wall and Combrink, 2006; Uilenberg, 2006) and are one of the most problematic issues in the livestock industry (Madder et al., 2011). The disease caused by these organisms and their vector, cattle fever ticks (CFT, *Rhipicephalus* (*Boophilus*) *microplus*, *R.* (*B.*) *annulatus*), were eradicated from the U.S. by 1943 by state and federal agencies under the Cattle Fever Tick Eradication Program. Because of widespread prevalence of CFT in neighboring states of Mexico, reintroduction is a significant threat (Pérez de León et al., 2014); thus, there is a permanent quarantine zone (PQZ) between Texas and Mexico (Pérez de León et al., 2012; Giles et al., 2014). The PQZ remains due to movement of tick host species such as white-tailed deer (*Odocoileus virginianus*, Kistner and Hayes, 1970), nilgai antelope (*Boselaphus tragocamelus*, Cárdenas-Canales et al., 2011), stray cattle (*Bos* spp.) and interactions between CFT and exotic weeds along the transboundary region with Mexico (Racelis et al., 2012; Esteve-Gassent et al., 2014). In recent years, there has been more infestation cases outside of the PQZ than within (Giles et al., 2014).

The expansion of CFT outside of the PQZ has resulted in a need to better understand movement of free-ranging host wildlife species. Two host species of concern in South Texas are white-tailed deer and nilgai. In South Texas, Moczygemba et al. (2012) reported mean home range sizes of 8355 and 9356 ha for female and male nilgai, respectively; whereas, mean home range size of male white-tailed deer ranges from 182 to 922 ha (Webb et al., 2007; Hellickson et al., 2008). Thus, nilgai have great potential to introduce CFT into new areas (Moczygemba et al., 2012). Nilgai are non-migratory and occur in small sexually segregated groups except during the breeding season (Leslie and Sharma, 2009). Males are reportedly transient (Sheffield et al., 1983) but nilgai movement patterns are relatively undocumented because the species were brought to Texas only at the beginning of last century and released into fenced areas in the southern part of the state. Because nilgai are not entirely impeded by fences (Sheffield et al., 1983), some nilgai eventually escaped and by the early 1970s, free-ranging nilgai were distributed in 9 Texas counties and in northeastern Mexico (Presnall, 1958; Sheffield et al., 1983). In Texas, nilgai are defined as an exotic species, which allows year-round hunting with no bag limits. Despite this, nilgai populations have become established and have expanded their range in Texas (Moczygemba et al., 2012).

There is a need to better understand nilgai movement patterns because long range movement of nilgai is now implicated in the spread of CFT not only in the PQZ along the Rio Grande, but also in the Temporary CFT Preventive Quarantine Areas (TPQZ) located north of the PQZ in Cameron, Willacy, and Kleberg Counties (Texas Animal and Health Commission, 2014). Recently, CFT has been found in several properties north of the TPQZ and south of state highway 186 in Willacy County (Fig. 1) prompting the expansion of CFT surveillance efforts. Understanding movement of nilgai and their home range is essential to establish effective quarantine boundaries to eradicate CFT. Failure to stop the spread of CFT could influence the cattle industry across much of the southern United States. To better understand how CFT may spread through the landscape via nilgai and to establish effective quarantine boundaries, this study had 3 objectives, to: 1) quantify home range size and evaluate whether seasonal movement patterns were driven by environmental conditions or physiological behavior, 2) evaluate nilgai response to 5 types of helicopter activities, and 3) measure permeability of three types of fences.

Although Moczygemba et al. (2012) found that home range sizes were similar between males and females, we hypothesized that male nilgai would have larger home range sizes and higher movement rates than females because sexual dimorphism suggests males have a greater nutritional demand (McNab, 1963) and males are reportedly transient (Sheffield et al., 1983). We also hypothesized seasonal changes in monthly movement patterns were a result of physiological changes (e.g., breeding, parturition, etc.). Alternatively, seasonal movement patterns may be a function of environmental conditions in semi-arid areas such as rainfall and temperature. Because nilgai may be sensitive to human disturbance (Sheffield et al., 1983), we predicted that nilgai would have higher movement rates during day(s) of helicopter activities in the study site, but most nilgai would remain on the study site because escape cover (i.e., canopy cover) is abundant (Goldstein et al., 2005). We hypothesized that fences running parallel with paved roads were the least permeable barrier relative to property boundary fences and intra-property fences.

2. Materials and methods

2.1. Study area

Nilgai were captured on a 10,984 ha property of the East Foundation bordering Port Mansfield, Texas (26°55′N, −97°42′E) immediately north of where current CFT infestations occur. Helicopter-based distance sampling in February 2015 indicated ~600 nilgai were present on the study site (Annala, 2015). The east boundary was the Gulf of Mexico, the north and west boundaries were adjacent to continuous landholdings, and the south boundary was state highway 186. The study site was surrounded by 1.25 m or 2.50 m high woven-wire fence to prevent exchange of cattle with adjacent properties. Fences were used to control cattle movements because unlike nilgai, cattle do not have the ability or propensity to go underneath fences. The study site overlapped 3 ecoregions; Coastal Sand Plains, Lower Rio Grande Valley, and Laguna Madre Coastal Marshes (Bailey et al., 1994). The Coastal Sand Plains and Lower Rio Grande Valley ecoregions were comprised of Tamaulipan thornscrub, oak forest and savannah, and grasslands. The Laguna Madre Coastal Marshes contained mosaics of coastal wetlands, ponds, and grasslands bordering the Laguna Madre. From April 2015 to May 2016, the sub-humid region received an average monthly rainfall of 6.66 cm (range = 0.03–20.90) and temperatures averaged 23.0° C (range = 13.6–28.3, Crop Weather Program, 2016).

2.2. Nilgai capture

In April 2015, we randomly captured thirty nilgai (5% of estimated population size) via helicopter net-gunning (Barrett 1982) and each nilgai was fitted with a satellite radio-collar. Captures were approved by Texas A & M University − Kingsville IACUC (no. 2015-03-30). We affixed two types of Lotek (Lotek Wireless Inc., Ontario, Canada) collars to nilgai; Globalstar (1-h fix interval, n = 10) and LifeCycle (13-h fix interval, n = 20). To extend lifespan of Globalstar batteries, fix intervals switched to 2-h after 1 year (April 2016). We did not collar calves (< 1 year old) because of their association with their dams. Mortalities (n = 1) and collar break-offs (n = 4) occurred during the study and these collars were re-deployed on new nilgai of the same sex via net-gunning (Table S1). Preliminary analyses indicated collared individuals did not interact with each other for extended periods of time; thus, we concluded we did not monitor individuals belonging to the same social group.

2.3. Home ranges

Prior to conducting movement analyses, the first 3 days post-collar