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Nilgai, *Boselaphus tragocamelus* and white-tailed deer, *Odocoileus virginianus* use of water troughs with and without remotely operated field sprayers for potential treatment of cattle fever ticks

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ABSTRACT

Nilgai antelope, *Boselaphus tragocamelus* and white-tailed deer (WTD), *Odocoileus virginianus* are hosts of cattle fever ticks, *Rhipicephalus* (=*Boophilus*) *microplus*, in the Lower Rio Grande Valley of South Texas. Daily use of water troughs and ponds were observed to determine if these locations could be used for field treatment methods for cattle fever ticks using remotely operated field sprayers. Game cameras (n=16) were deployed between June 2020 and September 2022 at two private ranches in Cameron County, TX. Both nilgai and WTD visited water troughs equipped with motion detecting sprayers in similar numbers to ponds, but numbers of animal visits were lower during periods of high rainfall when playa lakes formed. Water troughs may be ecologically friendly lure stations for treatment of cattle fever tick-infested wildlife. Further research is recommended for use of this system in the USDA-APHIS/Texas Animal Health Commission, Cattle Fever Tick Eradication Program.

Additional index words: Cattle fever ticks, livestock entomology, pathogenic landscape

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Hunting and ecotourism, especially surrounding megafauna, are an important part of North American culture. Among North American cervids (Cervidae), white-tailed deer (WTD), *Odocoileus virginianus* (Zimmerman) are considered the most important ungulates in both numbers and economic value (McCullough 1987, Conover 2011). In the United States, WTD have increased in density and distribution during the 20th century, following suppression due to habitat loss and overhunting in the early 1900's (McShea et al. 2003, Heffelfinger 2011).

In South Texas, nilgai antelope (Bovidae), *Boselaphus tragocamelus* (Pallas), play a similar role to WTD. Nilgai antelope are closely related to cattle (*Bos* spp.). They were brought to the United States from India and were apparently released in South Texas about 1930. By the early 1970s, they were distributed in nine Texas counties and in northeastern Mexico (Leslie and Sharma 2009). The suite of nilgai, white-tailed deer, and cattle in South Texas is of interest due to their cultural importance and the competence of these species as hosts of cattle fever ticks (CFT), *Rhipicephalus* (=*Boophilus*) *microplus* (Canestrini) and *Rhipicephalus* (*B.*) *annulatus* (Say) (Lohmeyer et al. 2018). Cattle fever ticks can transmit a tick-borne disease of veterinary importance, bovine babesiosis caused by *Babesia* (*B. bovis* and *B. bigemina*). Bovine babesiosis was once endemic in the southern United States and caused severe losses to the cattle industry. However, this disease and its vectors were eradicated from the United States by 1943. The successful eradication of CFT and bovine babesiosis is owed to efforts by the U.S. Department of Agriculture – Animal and Plant Health Inspection Service (USDA-APHIS), Texas Animal Health Commission, and the cooperation of landowners under the Cattle Fever Tick Eradication Program. Since the initial eradication of CFT, incursions of these ticks from endemic Mexico, have been a persistent problem. To prevent reintroduction of CFT and babesiosis, a quarantine area between Texas and Mexico is maintained (Perez de Leon et al., 2012; 2014; Giles et al., 2014, Olafson et al. 2018). The incursions of CFT beyond the permanent quarantine zone along the Rio Grande River have become more frequent in recent years (Giles et al., 2014). Several factors contribute to CFT incursions, including the increased density of wildlife hosts such as nilgai (Cardenas-Canales et al., 2011) and white-tailed deer (Kistner and Hayes, 1970), and the high frequency of stray cattle (*Bos* spp.) entering the US from Mexico. Additionally, exotic weeds along the trans-boundary region with Mexico form a pathogenic landscape that facilitates the invasion and survival of CFT (Racelis et al., 2012; Esteve-Gassent et al., 2014). Nilgai are wide-ranging ungulates that are largely unimpeded in their movements, see Goolsby et al. (2023). For this reason, nilgai have been implicated as an important contributor in the spread of CFT in South Texas. Therefore, nilgai are important contributors in the establishment of new temporary preventative CFT quarantine areas, (Foley et al. 2017, Lohmeyer et al. 2018).

Due to the complexity of managing and eradicating ticks, several tools are employed by the Cattle Fever Tick Eradication Program. Ivermectin treated 'medicated' corn is a commonly used tool for managing CFT on WTD. Another tool is the remotely operated spray systems with sonic sensors, which have been developed for treatment of CFT-infested nilgai with entomopathogenic nematodes as they pass through established fence crossings (Goolsby et al. 2019). A remotely operated sprayer could be particularly effective in areas where nilgai dispersal has been reduced by the placement of game fencing (Goolsby et al. 2023). However, the difficulty of treatment of nilgai at fence crossings or other locations has complicated the implementation of these tools. Water troughs have potential as effective treatment locations for nilgai and WTD, especially across the drought prone landscape of southern Texas. Our objectives were to (1) document activity patterns for nilgai at man-made water troughs and ponds, (2) evaluate interactions of water use patterns for nilgai and WTD with rainfall, and (3) determine if the presence of remotely operated sprayers at water troughs affects the water use by nilgai and WTD.

MATERIALS AND METHODS

Study Sites. Research was conducted from June 2020 to April 2022 at Russell and Buena Vista Ranches located in southeastern Cameron County, TX (Fig. 1). The ranches are situated in the sub-tropical Tamaulipan thorn scrub region, which receives an average rainfall of 60 cm annually with average daily temperatures ranging from 19-27 °C. The study sites are characterized by a dense chaparral of honey mesquite (*Prosopis glandulosa* Torr.) and huisache (*Vachellia farnesiana* (L.) Willd.) savannah dominated by Guineagrass (*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs) and buffelgrass (*Cenchrus ciliaris* L.). Both Russell and Buena Vista ranches had free-ranging nilgai and WTD, but cattle were present only at the Buena Vista Ranch. Historical weather data for the duration of the study was obtained from Weather Underground repository (https://www.wunderground.com/history).
Monthly weather readings from the Cameron County Airport in Laguna Vista, TX, were used for analysis. In this study, during months where weather data was unavailable from the Cameron County Airport, data from the closest available weather station was used.

The study consisted of a total of eight water troughs; four control troughs (no remotely operated sprayers) at Buena Vista Ranch, and four treatment troughs at Russell Ranch at which remotely operated sprayers were placed. Metal fencing was installed to block access to each trough except at one end (Fig 2). The sprayers were triggered with a sonic sensor when animals approached the water trough. Three nozzles were aimed to spray away from the trough and treat the front, middle and rear of the animal. The sprayers were maintained weekly to ensure consistent spray applications. A Reconyx Hyperfire 2 game camera (Holmen, Wisconsin) was set up at each water trough to record the time and frequency of animal visits. Additionally, we set game cameras at one pond at the Russell Ranch, and cameras at two ponds at the Buena Vista Ranch. All ponds were located within 500m of a water trough.

Fig. 1. The location of study sites in Cameron County, TX

Data collection and analysis. Activity of nilgai and WTD were determined by examination of digital images. We recorded the total number of observations by species, trough type (Treatment with sprayer vs. no sprayer Control) and pond locations from June 2020 to April 2022. We followed the Federal Response Plan for Employee Health and Safety and Continuity of Operations in a Human Pandemic, to conduct our field work. We defined an observation as a clearly identifiable picture of a nilgai or WTD. In some cases, there were multiple pictures of the same animal during an observation period and in these cases, we counted this as one observation. Statistical analysis was conducted in the statistical software package R (R Core Team, 2020), using the built in statistical packages STATS (version 4.2.2) and MASS (version 7.3-60). To analyze count data, we first tested for normality using a

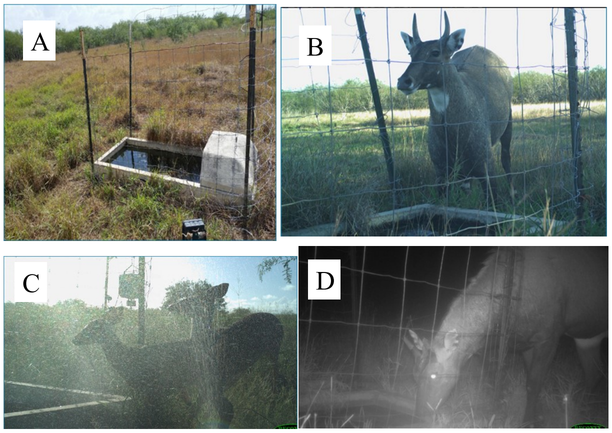

Fig 2. (A) Water trough with fencing and remotely operated sprayer, (B) nilgai approaching water trough, (C) white-tailed deer being sprayed at water trough, (D) nilgai drinking and activating sprayer at trough.

Bartlett test, and tested for unequal variance using Levene's test. Finally, we evaluated the dispersion statistic to determine which model would be most appropriate. We determined that a negative-binomial model would be most appropriate due to the high proportion of zeros in the data. We compared the total number of nilgai and WTD recorded per month against treatment method (sprayer vs. no sprayer) and included cm of rain per month as an additive variable, to account for rain in the model.

RESULTS

Table 1. Total number of nilgai and white-tailed deer ± SE* at water sources at two separate ranches in Cameron County between June 2020 and April 2022.

Water Source	Nilgai	WTD	DF
Russell (Treatment)	280.25 ± 169.15[a]	295.5 ± 78.25[a]	3
Buena Vista (Control)	20.5 ± 7.88[b]	22.75 ± 9.88[b]	3
Russell Pond (Treatment) **	204	33.5	1
Buena Vista Ponds (Control)**	28	0	0

*Means and standard errors per site by column with different letters are significantly different ($p < 0.01$)
**Total numbers per location presented in table.

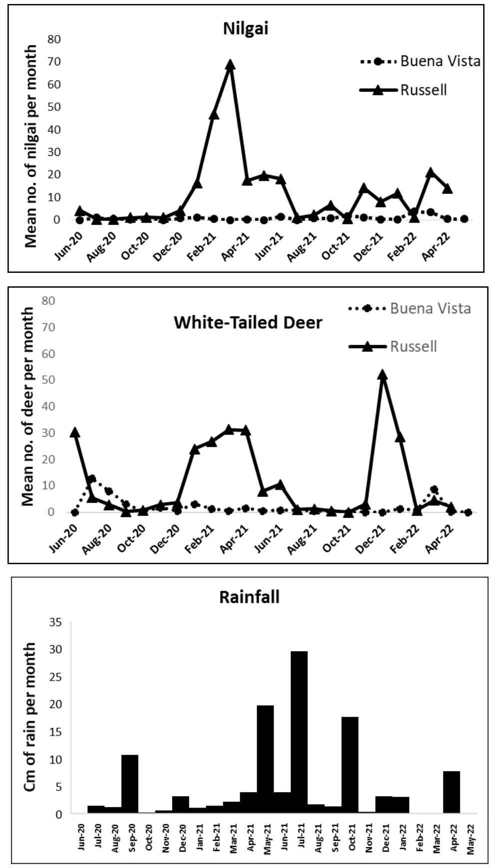

Fig 3. Mean of nilgai and WTD per month at water troughs at Russell Ranch (with sprayers) and Buena Vista Ranch (no sprayers) in Cameron County with rainfall between June 2020 and May 2022.

Nilgai and WTD visitations were significantly higher ($P < 0.01$) at water troughs with remotely operated sprayers than water troughs with no sprayers (Table 1). There was no significant effect ($P = 0.07$) cm of rain on nilgai counts, though the model predicts that there is a negative trend between nilgai count and cm of rain *estimate* = -0.051 (Fig. 3). There was a significant effect ($P = 0.014$) of sprayer presence at water trough for WTD detection, with greater numbers of WTD being predicted on treated sites. There was also a significant effect ($P = 0.014$) of rain on WTD visits to troughs with fewer deer being predicted with higher amounts of rainfall. We recorded a high level of variation between water troughs at both study sites see Table 1. The trend of nilgai and WTD visits to troughs were similar between troughs and ponds at both locations over the total length of the study.

DISCUSSION

This study clearly shows that nilgai and WTD will visit water troughs even with activated remotely operated sprayers. Access to quality water during periods of dry weather appears to be an important ecological factor influencing animal behavior in an arid, subtropical climate. Our data suggests that during periods of wet weather when playa lakes form, nilgai and WTD visits to water troughs were marginally significantly and significantly lower, respectively. Even after rainfall WTD continued to visit water troughs, which may indicate a more habitual behavior for this species. Use of water trough sprayers to treat CFT infested wildlife may not be practical or productive following periods of high rainfall. Bellow et al. (2001) found that WTD selected for habitats with proximity to water-troughs in additional to thermal cover and food. Little is known about habitat selection by nilgai in reference to water availability, but their home ranges are large enough such that they may not select for habitat with close proximity to water, but rather to food quality and brush cover. One of the most striking differences between the two study sites was the much lower number of nilgai and WTD at the water troughs at Buena Vista Ranch. The large amount of variation between sites necessitated the use of both treatments, regardless of use/variation for analyses. The landscape and plant community appear to be very similar between both ranches. The most obvious difference is the presence of cattle at Buena Vista Ranch and the presence of brackish ponds adjacent to the Laguna Madre. These differences appear to indicate reluctance of the wildlife to come to water troughs in the presence of cattle and/or a difference in overall water availability between sites. None of the game camera images at water troughs showed both cattle and wildlife together at the same time, which supports this hypothesis. Additional field research is needed to determine if this apparent competition is significant and how this might impact use of water trough sprayers in mixed populations of cattle and wildlife.

Use of the botanical pesticide, Stop the Bites ® (STB) has been tested for repellency effects on WTD with sprayers and was found to have little to no effect of visits by WTD to corn feeders (Goolsby et al. 2022). Additionally, the use of entomopathogenic nematodes has been shown to cause significant mortality to CFT (Singh et al. 2018) and have been deployed in a motion detecting sprayer (Goolsby et al. 2019). Entomopathogenic nematodes and botanical insecticides are two prime candidates for future application using treatment stations like water trough-sprayer combinations and are environmentally friendly for use in biologically sensitive areas.

In summary, water troughs are suitable locations for treatment of the culturally important nilgai and WTD infested with cattle fever ticks. Water troughs with sprayers could be a tool for treatment of CFT infested wildlife and/or cattle. Additional research is needed to document the impact of water trough sprayers on infestation levels of CFT and other ticks on nilgai and WTD. On-going satellite collaring efforts to monitor movements of nilgai at Laguna Atascosa Wildlife Refuge (Maestas & Goolsby unpublished data) could be used to segregate tick count data from nilgai that accessed the water trough sprayers vs. those in the same environment that were not treated. In a broader sense, on-going and proposed research studies could lead to a novel method for treatment of wildlife using water trough sprayers.

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LITERATURE CITED

Bellow, J. S. Gallina, M. Equihua. 2001. Characterization and habitat preferences by white-tailed deer in Mexico J. Range Manage. 54: 537–545.

Cardenas-Canales, E.M., Ortega-Santos, J.A., Campbell, T.A., Garcia-Vazquez, Z., Cantu-Covarrubias, A., Figueroa-Millan, J.V., DeYoung, R.W., Hewitt D.G., Bryant F.C., 2011. Nilgai in northern Mexico as a possible carrier for cattle fever ticks and *Babesia bovis* and *Babesia bigemina*. J. Wildl. Dis. 47: 777-779.

Conover, M.R., 2011. Chapter 13: Impacts of Deer on Society. D.G. Hewitt (Ed.), Biology and Management of White-tailed Deer, CRC Press, Boca Raton, FL, USA, pp. 400-406.

Esteve-Gassent, M.D., Perez de Leon, A.A., Romero-Salas, D., Feria-Arroyo, T.P., Patino, R., Castro-Arellano, I., Gordillo-Perez, G., Auclair, A., Goolsby, J., Rodriguez-Vivas, R.I., Estrada-Franco, J.G., 2014. Pathogenic landscape of transboundary zoonotic diseases in the Mexico-US border along the Rio Grande. Front. Pub. Hlth. 2: 1-23.

Foley, A.M., J.A. Goolsby, A. Ortega-S Jr., J. Ortega-S Sr., A. Pérez de León, N.K. Singh, A. Schwartz, D. Ellis, D. G. Hewitt, and T.A. Campbell. 2017. Movement patterns of nilgai antelope in South Texas: implications for cattle fever tick management. Preventive Veterinary. Medicine. 146: 166-172.

Giles, J.R., Peterson, A.T., Busch, J.D., Olafson, P.U., Scoles, G.A., Davey, R.B., Pound, J.M., Kammlah, D.M., Lohmeyer, K.H., Wagner, D.M., 2014. Invasive potential of cattle fever ticks in the southern United States. Parasit. Vectors 7: 189.

Goolsby, J.A., D. Cantu, A. Vasquez, A. E. Racelis, W. C. Hoffmann, P. Jank, R. Garcia III, D. Shapiro-Ilan, J. Hinojosa, C. Reed, D. Bonilla, D. Ellis, and A. Perez de Leon. 2019. Development of a remotely activated field sprayer and evaluation of temperature and aeration on the longevity of *Steinernema riobrave* entomopathogenic nematodes for treatment of cattle fever tick infested nilgai. Subtropical Agriculture and Environments. 70: 1-5.

Goolsby, J.A., L.P. Maestas, P. Saelao and K.H. Lohmeyer. 2022. Evaluation of the repellency of Stop the Bites® acaricide to white-tailed deer at corn feeders. Southwestern Entomologist 47: 277-284.

Goolsby, J.A., L.P. Maestas, R. Garcia, M. May, K. H. Lohmeyer, J. Picanso, D. Anderson, J. Coy, and D. Bonilla. 2023. Preventative methods to reduce the spread of cattle fever ticks on wildlife and protect local endangered species in South Texas. Southwestern Entomologist. 48: 289-302.

Heffelfinger, J.R., 2011. Chapter 1: taxonomy, evolutionary history, and distribution. D.G. Hewitt (Ed.), Biology and Management of White-tailed Deer, CRC Press, Boca Raton, FL, USA (2011), pp. 3–39.

Kistner T.P., Hayes F.A., 1970. White-tailed deer as hosts of cattle fever-ticks. J. Wildl. Dis. 6: 437-440.

Leslie D.M., Sharma K., 2009. *Tetracerus quadricornis* (Artiodactyla: Bovidae). *Mammalian Species Archive* 843: 1-11.

Lohmeyer, K.H., M.A. May, D.B. Thomas, and A.A. Pérez de León. 2018. Implication of Nilgai Antelope (Artiodactyla: Bovidae) in Reinfestations of *Rhipicephalus (Boophilus) microplus* (Acari: Ixodidae) in South Texas: A Review and Update. J. of Medical Entomology. 55: 512-522.

McCullough, D.R. 1987. The theory and management of *Odocoileus* populations. In Wemmer, C. M. editor, Biology and Management of the Cervidae. pp. 535-549.

McShea, W.J., Underwood, H.B. and Rappole, J.H. 2003. Deer management and the concept of overabundance. In McShea, W.J., Underwood, H.B. and Rappole, J.H. editors. The science of overabundance: Deer ecology and population management. Smithsonian Books, Washington, D.C., USA. pp. 1-10.

Olafson, P.U., D.B. Thomas, M.A. May, B.G. Buckmeier, and R.A. Duhaime. 2018. Tick vector and disease pathogen surveillance of nilgai antelope (*Bosephalus tragocamelus*) in southeastern Texas, USA. Journal of Wildlife Diseases. 54: 734-744.

Perez de Leon A.A., Pete T.D., Auclair A.N., Messenger M.T., Guerrero F., Schuster G., Miller R.J. 2012. Integrated strategy for sustainable cattle fever tick eradication in U.S.A. is required to mitigate the impact of global change. Front in Physiology, 3: 1-17.

Racelis, A.E., Davey, R.B., Goolsby, J.A., Perez de Leon, A.A., Varner, K., Duhaime, R., 2012. Facilitative ecological interactions between invasive species: *Arundo donax* (Poaceae) stands as favorable habitat for cattle ticks (Acari: Ixodidae) along the US-Mexico border. J. Med. Entomol. 49: 410-417.

Singh, N.K., J. A. Goolsby, D. I. Shapiro-Ilan, R. J. Miller, D. B. Thomas, G. M Klafke, J. P. Tidwell, A. E. Racelis, P. S. Grewal, and A. A. Perez de Leon. 2018. Efficacy Evaluation of Six Entomopathogenic Nematode Species against Engorged Females of Southern Cattle Fever Tick, *Rhipicephalus* (=*Boophilus*) *microplus*. Southwestern Entomologist. 43: 1-18.