Rangeland Ecol Manage 64:316–318 | May 2011 | DOI: 10.2111/REM-D-10-00158.1

Research Note

A Mark–Recapture Technique for Monitoring Feral Swine Populations

Matthew M. Reidy,[1] Tyler A. Campbell,[2] and David G. Hewitt[3]

Authors are [1]Wildlife Biologist, Texas Parks and Wildlife Department, Pleasanton, TX 78064, USA; [2]Research Wildlife Biologist, US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Texas Field Station, Kingsville, TX 78363, USA; and [3]Research Scientist and Associate Professor, Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA.

Abstract

Techniques to monitor populations of feral swine (*Sus scrofa*) relative to damage control activities are needed on rangelands. Our objectives were to describe and assess a mark–recapture technique using tetracycline hydrochloride (TH) for monitoring feral swine populations. We established bait stations at study sites in southern and central Texas. During 1 d, we replaced normal soured corn bait with bait containing TH and counted the number of feral swine that consumed bait with observers. We conducted feral swine removal using box-style traps and helicopters, at which time we collected teeth for TH analysis. In southern Texas, we estimated population reduction to be 43%. In central Texas, we estimated population reduction of 31%. Our mark–recapture population monitoring technique would complement programs to manage feral swine populations and damage through lethal control.

Resumen

Se necesitan técnicas para monitorear poblaciones de cerdos ferales (*Sus scrofa*) para actividades de control de daños en pastizales naturales. Nuestros objetivos fueron describir y evaluar una técnica de marca–recaptura utilizando hidrocloruro de tetraciclina (HT) para monitorear las poblaciones de cerdos ferales. Establecimos estaciones con cebo en las áreas de estudio en el sur y el centro de Tejas. Durante un día, remplazamos el cebo de maíz fermentado con cebo conteniendo HT y con observadores, contamos el número de cerdos ferales que consumieron el cebo. En el sur de Tejas, se estimó una reducción del 43% de la población. En el centro de Tejas, la reducción estimada fue del 31% de la población. Nuestra técnica de monitoreo de marca–recaptura podría complementar programas de manejo de control letal de las poblaciones de cerdos ferales y los daños que los mismos ocasionan.

Key Words: density, pig, *Sus scrofa*, tetracycline hydrochloride, wild hog, wildlife damage management

INTRODUCTION

Feral swine (*Sus scrofa*) pose a significant threat to agriculture and the environment (Seward et al. 2004). They are implicated in economic and environmental damages, including consumption of crops; predation of livestock, ground-nesting birds, reptiles, and amphibians; disease transmission; soil erosion; destruction of habitat; and competition with native wildlife (Campbell and Long 2009). Feral swine are found on every continent except Antarctica and were first brought to North America by European explorers and settlers (Towne and Wentworth 1950; Sweeney et al. 2003). Established populations occur in most states of the United States, where they are rapidly expanding into new areas (National Feral Swine Mapping System 2010).

Land managers often use a variety of lethal control methods to combat growing feral swine problems. Population indices and density estimates are tools for monitoring the effectiveness of these control methods (Cowled et al. 2006). However, population monitoring techniques used for native ungulates are often not effective for feral swine in many rangeland ecosystems (Reidy 2007). Therefore, a need in feral swine damage management is a method of monitoring populations of feral swine relative to control activities (Sweitzer et al. 2000; Sweeney et al. 2003).

Traditional mark–recapture techniques to evaluate densities of free-ranging wildlife are hindered by logistical constraints, cost, and time (Sweitzer et al. 2000). Ingestible biological markers have been used to mark and estimate population size of several species of wildlife. One biological marker that is valuable in wildlife management is tetracycline hydrochloride (TH), a palatable and ingestible antibiotic that establishes a permanent fluorescent mark on growing bone and teeth (Milch et al. 1957). Managers have used TH to quantify populations of black bears (*Ursus americana*; Garshelis and Visser 1997) and polar bears (*Ursus arctos*; Taylor and Lee 1994), measure the use of supplemental feed by white-tailed deer (*Odocoileus virginianus*; Bartoskewitz et al. 2003), and determine the feasibility of delivering pharmaceuticals to white-tailed deer (Van Brackle et al. 1994). Herein, we report estimates of feral swine population size before lethal removal and population

Research was funded by the US Department of Agriculture, Animal and Plant Health Inspection Services, Wildlife Services, National Wildlife Research Center.

Our mention of commercial products herein is for identification purposes and does not constitute endorsement or censure by the US Department of Agriculture.

At the time of the research, Reidy was a Research Assistant, Caesar Kleberg Wildlife Research Institute, Texas A&M University–Kingsville, Kingsville, TX 78363, USA.

Correspondence: Tyler A. Campbell, US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Texas A&M University–Kingsville, 700 University Blvd, MSC 218, Kingsville, TX 78363, USA. Email: tyler.a.campbell@aphis.usda.gov

Manuscript received 6 October 2010; manuscript accepted 9 January 2011.

reduction after removal on two Texas rangelands. Our objectives were to describe and assess a mark–recapture technique using TH for monitoring feral swine populations.

METHODS

Study Areas

Our study area in southern Texas was the Rob and Bessie Welder Wildlife Refuge (WWR), which was approximately 12.8 km north of Sinton in San Patricio County, Texas (lat 28°06′N, long 97°22′W). The WWR consisted of approximately 32 km^2 bordered to the north by the Aransas River, the west by US Highway 77, and the south and east by private rangeland. Topography was flat with elevations ranging from 0 to 14 m above sea level (Ilse and Hellgren 1995). Habitat was characteristic of both the Gulf Prairies and Marshes and South Texas Plains ecoregions (Drawe et al. 1978). Our study area in central Texas was Fort Hood, which was located in Bell and Coryell County, Texas, and encompassed 879 km^2. It was an active military base surrounded by private land on the eastern edge of the Edward's Plateau ecoregion within the Lampasas Cut Plains physiographic region (Raisz 1952). Our specific study site was Training Area 36 located on the southeast corner of Fort Hood (lat 31°06′N, long 97°34′W). It was approximately 10 km^2 in size, bordered to the south and east by private rangeland and to the north and west by Fort Hood training land. Training Area 36 was characteristic of Fort Hood and consisted of shallow soils and limestone uplifted mesas ranging from 40 to 80 m high (Weinberg et al. 1998).

Methods

We established six bait stations $\geq$ 1 km apart on the WWR and four bait stations $\geq$ 800 m apart on Fort Hood. Each station consisted of 2×2 m of cleared ground with a metal T-post at one end to facilitate camera placement. Stations were baited daily with approximately 6 kg corn soured in water for 24–48 h. Stations were continuously monitored with Silent Image™ Professional (RECONYX, La Crosse, WI, USA) motion-sensitive continuous video cameras. When we determined that feral swine were consistently using bait stations, we baited each station with approximately 24 kg of TH-treated soured corn on 1 d. We placed TH-treated corn out between 1500 and 1600 h. Feral swine need to ingest $\geq$ 200 mg TH to be adequately marked, and these marks have been identified in feral swine teeth $\geq$ 7 d postingestion (Fletcher et al. 1990; Reidy et al. 2008). We prepared TH-treated corn by placing 12 kg of corn in plastic buckets with 2 L of water for 24–48 h and mixing the soured corn with 10 000 mg of powdered TH (IVAX Pharmaceuticals, Inc., Miami, FL, USA) for 4 min in a 100-L electric cement mixer (RED LION, Monarch Industries, Winnipeg, Manitoba, Canada). The TH concentration was approximately 400 mg $\cdot$ 0.45 kg^{-1} soured corn as per previous studies with ungulates of similar body size (Van Brackle et al. 1994). We placed an observer in a blind 30–100 m from each bait station. The observer counted the number of feral swine consuming TH-treated soured corn and removed all TH-treated soured corn once a group of swine had eaten and moved away. This prevented the possibility of double counting individual feral swine.

We used 14 feral swine box-style traps on the WWR and 6 box-style taps on Fort Hood. All traps were > 200 m from previously mentioned bait stations. All traps were tied open and prebaited with soured sorghum rather than corn to reduce bias associated with feral swine accustomed to eating corn. We set traps for 84 trap nights on the WWR and 60 trap nights on Fort Hood. Additionally, we used a helicopter to remove swine over 1 d on each study area. We collected mandibles from all swine removed. Mandibles were boiled for approximately 3 h, and teeth were removed. Teeth were sectioned to 100–150 μm longitudinally and examined microscopically under ultraviolet light for the presence of the TH marker (Fletcher et al. 1990). All procedures were approved by the Institutional Animal Care and Use Committee at the National Wildlife Research Center (Protocol No. QA-1309).

We used the Lincoln–Peterson index to obtain a population estimate from the ratio of TH marked to unmarked feral swine in the sample (White 1996). We used the joint hypergeometric maximum likelihood estimator because of the single voluntary mark event and no recaptures due to lethal removal. We obtained a population abundance estimate and reported means with 95% confidence intervals in parentheses.

RESULTS

On our rangeland site in southern Texas, we identified 65 feral swine consuming TH-treated soured corn at bait stations. We captured and removed 87 feral swine using box traps. Furthermore, we removed 19 feral swine by helicopter for a total of 106 feral swine removed. We found 37 of the removed animals to have TH-marked teeth. From this, we determined population estimates for feral swine before removal to be 184.8 (154.3–215.3) swine and an estimated population reduction of 43%. Including removal, our mark–recapture technique used 415 person-hours to complete. On our rangeland site in central Texas, we identified 13 feral swine consuming TH-treated sour corn at bait stations. We captured and removed 17 feral swine using box traps. Additionally, we removed two feral swine by helicopter for a total of 19 feral swine removed. We found four of the removed animals to have TH-marked teeth. From this, we determined population estimates for feral swine before removal to be 55.0 (23.9–86.1) swine and an estimated population reduction of 31%. Including removal, our mark–recapture technique used 185 person-hours to complete.

DISCUSSION

We found TH to be a suitable marker for mark–recapture estimates of feral swine on our study sites. Feral swine readily ingested TH combined with soured corn bait. However, TH is a permanent marker, and care should be taken if it is to be reused on a single area (Garshelis and Visser 1997).

The mark–recapture technique that we describe has six advantages over traditional population monitoring techniques. First, this technique uses a single voluntary marking event, and there is no need to capture animals initially to mark animals with an ear-tag, collar, tattoo, or PIT tag. This reduces cost expenditures associated with animal capture and handling and may increase the probability of future animal captures for removal. Second, in situations in which reduction of feral swine numbers is an objective, this technique has an advantage in that trapped swine can be euthanized instead of being released for future recapture. Therefore, this technique complements lethal control programs for feral swine. Third, this technique allows for a narrow mark and recapture window, which limits biases due to violation of the assumption of population closure. For example, the duration from marking to recapture was < 53 d on the WWR and < 34 d on Fort Hood. Therefore, the amount of time available for immigration or emigration events to occur was minimal. Fourth, different methods of recapture can be used with this technique. For example, we used two different techniques, trapping and aerial control, to ensure that we sampled trap-shy animals. Fifth, this technique provides a population estimate with a measure of variance, unlike other techniques like tracking indices (e.g., see Engeman et al. 2007). Finally, this technique allows for the calculation of the proportion of feral swine population removed during lethal control activities by using the proportion of marked swine in the sample that were removed. This information is critical to natural resource managers needing to provide assessments of management activities to decision makers. This mark–recapture population monitoring technique would complement programs to manage feral swine populations and damage through lethal control.

MANAGEMENT IMPLICATIONS

Use of biomarkers and lethal removal to estimate feral swine populations will be appropriate in situations where swine are visible at bait sites and susceptible to trapping or aerial gunning (Campbell et al. 2010). Where these criteria cannot be met, other techniques, such as tracking indices (Engeman et al. 2007) or traditional mark–recapture techniques (Sweitzer et al. 2000), could be employed. Our data suggest that 2–3 wk of trapping and 1 d of shooting swine from a helicopter resulted in removal of 31–43% of the estimated feral swine population. Additional studies using different levels of effort to remove feral swine could establish a relationship between effort and percent of a population removed. Such a relationship would be valuable in cost–benefit analyses of efforts to control feral swine damage.

ACKNOWLEDGMENTS

We thank the Rob and Bessie Welder Wildlife Foundation and Fort Hood Directorate of Public Works, Environmental Division, Natural Resources Management Branch, for access to their properties. We are grateful to T. Blankenship, K. Cagle, J. Delgado-Acevedo, D. Long, M. Ply, A. Tjelmeland, and E. Wehland for assistance. This is publication number 09-107 from the Caesar Kleberg Wildlife Research Institute.

LITERATURE CITED

Bartoskewitz, M. L., D. G. Hewitt, J. S. Pitts, and F. C. Bryant. 2003. Supplemental feed use by free-ranging white-tailed deer in southern Texas. *Wildlife Society Bulletin* 31:1218–1228.

Campbell, T. A., and D. B. Long. 2009. Feral swine damage and damage management in forested ecosystems. *Forest Ecology and Management* 257:2319–2326.

Campbell, T. A., D. B. Long, and B. R. Leland. 2010. Feral swine behavior relative to aerial gunning in southern Texas. *Journal of Wildlife Management* 74:337–341.

Cowled, B. D., S. J. Lapidge, J. O. Hampton, and P. B. S. Spencer. 2006. Measuring the demographic and genetic effects of pest control in a highly persecuted feral pig population. *Journal of Wildlife Management* 70:1690–1697.

Drawe, D. L., T. W. Box, and A. D. Chamrad. 1978. Plant communities of the Welder Wildlife Refuge. Sinton, TX, USA: Welder Wildlife Foundation, Report Number 5, Serial B/Revised.

Engeman, R. M., A. Stevens, J. Allen, J. Dunlap, M. Daniel, D. Teague, and B. Constantin. 2007. Feral swine management for conservation of an imperiled wetland habitat: Florida's vanishing seepage slopes. *Biological Conservation* 134:440–446.

Fletcher, W. O., T. E. Creekmore, M. S. Smith, and V. F. Nettles. 1990. A field trial to determine the feasibility of delivering oral vaccines to wild swine. *Journal of Wildlife Diseases* 26:502–510.

Garshelis, D. L., and L. G. Visser. 1997. Enumerating megapopulations of wild bears with an ingested biomarker. *Journal of Wildlife Management* 61:466–480.

Ilse, L. M., and E. C. Hellgren. 1995. Spatial use and group dynamics of sympatric collared peccaries and feral hogs in southern Texas. *Journal of Mammalogy* 76:993–1002.

Milch, R. A., D. P. Rall, and J. E. Tobie. 1957. Bone localization of the tetracyclines. *Journal of the National Cancer Institute* 19:87–93.

National Feral Swine Mapping System. 2010. Southeastern Cooperative Wildlife Disease Study. Available at: http://128.192.20.53/nfsms/index.jsp. Accessed 21 April 2010.

Raisz, E. 1952. Land forms of the United States. Washington, DC, USA: International Geological Congress.

Reidy, M. M. 2007. The efficacy of electric fencing to inhibit feral pig movements and evaluation of population estimation techniques for feral pigs in southern Texas [thesis]. Kingsville, TX, USA: Texas A&M University–Kingsville. 51 p.

Reidy, M. M., T. A. Campbell, and D. G. Hewitt. 2008. Tetracycline as an ingestible biological marker for feral pigs. *Proceedings of the Vertebrate Pest Conference* 23:210–212.

Seward, N. W., K. C. Vercauteren, G. W. Witmer, and R. M. Engeman. 2004. Feral swine impacts on agriculture and the environment. *Sheep and Goat Research Journal* 19:34–40.

Sweeney, J. R., J. M. Sweeney, and S. W. Sweeney. 2003. Feral pigs. *In:* G. Feldhamer, B. Thompson, and J. Chapman [eds.]. Wild mammals of North America. Baltimore, MD, USA: Johns Hopkins University Press. p. 1164–1179.

Sweitzer, R., D. Van Vuren, I. A. Gardner, W. M. Boyce, and J. D. Waithman. 2000. Estimating sizes of wild pig populations in the north and central coast regions of California. *Journal of Wildlife Management* 64:531–543.

Taylor, M., and J. Lee. 1994. Tetracycline as a biomarker for polar bears. *Wildlife Society Bulletin* 22:83–89.

Towne, C. W., and E. N. Wentworth. 1950. Pigs from cave to cornbelt. Norman, OK, USA: University of Oklahoma Press. 305 p.

Van Brackle, M. D., S. B. Linhart, T. E. Creekmore, V. F. Nettles, and R. L. Marchinton. 1994. Oral biomarking of white-tailed deer with tetracycline. *Wildlife Society Bulletin* 22:483–488.

Weinberg, H. J., T. J. Hayden, and J. D. Cornelius. 1998. Local and installation-wide black-capped vireo dynamics on the Fort Hood, Texas military installation. US Army Construction Engineers Research Laboratories Technical Report 98/54. Available at: http://www.cecer.army.mil/techreports/hay_vire.lln/hay_vire.LLN.htm#TopOfPage. Accessed 22 April 2010.

White, G. C. 1996. NOREMARK: population estimation from mark-resighting surveys. *Wildlife Society Bulletin* 24:50–52.