Human–Wildlife Conflicts 1(2):186–191, Fall 2007

Distribution and disease prevalence of feral hogs in Missouri

R. Edwin Hartin, USDA/APHIS/National Wildlife Services, 1714 Commerce Court, Suite C, Columbia, MO 65202, USA

Mark R. Ryan, Department of Fisheries and Wildlife Sciences, 302 Anheuser-Busch Natural Resources Building, University of Missouri-Columbia, Columbia, MO 65211, USA

Tyler A. Campbell, USDA/APHIS/National Wildlife Services' National Wildlife Research Center, Texas A&M University-Kingsville, MSC 218, 700 University Boulevard, Kingsville, TX 78363, USA *tyler.a.campbell@aphis.usda.gov*

***Abstract*:**
No attempts have been made to document the distribution of feral hogs (*Sus scrofa*) in Missouri. Also, antibody prevalence for pseudorabies virus and swine brucellosis have not been reported from Missouri. Our objectives were to characterize the current distribution of feral hogs in Missouri and to determine prevalence and distribution of feral hogs with antibodies against selected important diseases. We collected feral hog sighting data both from the public and Missouri Wildlife Services and Missouri Department of Conservation wildlife biologists. We determined prevalence of antibodies against pseudorabies virus, swine brucellosis, tularemia, and classical swine fever. From 2000 to 2005, the public reported 115 hog sightings statewide. We evaluated 321 feral hog sera for antibody presence from 1993 to 2005. Antibodies against pseudorabies virus and classical swine fever were not detected; however, 1 feral hog had antibodies against swine brucellosis (0.3% prevalence) and 1 feral hog had antibodies against tularemia (1.3% prevalence). Continued disease surveillance is critical to be able to react to any diseases that are found and eliminate them before they become established in feral hog populations in Missouri.

***Key words*:** classical swine fever, feral hog, human–wildlife conflicts, Missouri, pseudorabies virus, *Sus scrofa*, swine brucellosis, tularemia

During the settlement of Missouri, livestock were allowed to roam freely, and it was the responsibility of landowners, not livestock owners, to fence their properties to exclude domestic swine and other livestock. State law was changed in 1873 allowing individual counties to determine who was responsible for fences to control livestock. Since the free range of livestock ended statewide in 1969 (T. A. Hutton, U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services, unpublished report) there have been feral hogs (*Sus scrofa*) in several Missouri counties, primarily south of Interstate Highway 44. These populations have been sporadically augmented by intentional or accidental escapes. In the early 1990s, landowners began raising and promoting European wild boar (*Sus scrofa*) as a form of alternative agriculture and for hunting on controlled-shooting areas. Also during the 1990s, pork prices declined precipitously, and many domestic swine were released by owners due to economic hardship. This, in turn, resulted in a sharp increase in the abundance and range of feral hogs in Missouri. However, no attempts have been made to formally document the statewide distribution of feral hogs.

Feral hogs harbor numerous viral and bacterial diseases (Williams and Barker 2001, Kaller et al. 2007) and can spread disease to humans (Conover and Vail 2007). Additionally, feral hogs are susceptible to many internal and external parasites, such as nematodes, roundworms, flukes, lice, and ticks (Samuel et al. 2001). Many diseases that feral hogs are vulnerable to are also transmissible to livestock, wildlife, and humans. Of particular concern are pseudorabies virus (PRV), bovine tuberculosis (TB), swine brucellosis, vesicular stomatitis, tularemia, and leptospirosis. There is also growing trepidation about the role feral hogs would play in the event of an accidental or intentional outbreak of a foreign animal disease, such as foot and mouth, rinderpest, African swine fever, or classical swine fever (Witmer et al. 2003).

Disease surveillance and monitoring has

been conducted in several states because of feral hog disease threats to livestock. In a review of PRV surveillance activities within feral hogs, Müller et al. (2000) reports prevalence rates of >42% in Hawaii, 36% in Texas, 35% in Florida, 19–22% in the southeastern states, and 3% in California. Similar variability has been reported in prevalence rates of swine brucellosis. For example, prevalence rates of brucellosis in feral hogs were 53% in Florida (Becker et al. 1978), 18% in South Carolina (Wood et al. 1976) and 3% in Texas (Corn et al. 1986). No data pertaining to feral hog PRV and swine brucellosis antibody prevalence within Missouri feral hogs have been reported in the literature.

Swine brucellosis, TB, and PRV are among several diseases that affect livestock for which the U.S. Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS) has implemented national eradication programs. The goal of these programs is to eliminate these diseases from all livestock in the United States. Growing feral hog populations in Missouri and nationwide are complicating efforts to achieve these goals. However, all states were successful in reaching disease-free status for PRV in late 2004; this has served to shift some of the focus from domestic to feral hogs, as transmission between these groups of animals is suspected, yet poorly understood (Witmer et al. 2003).

We report here information generated through Missouri's Feral Swine Task Force (MFSTF). This 16-government agency and nongovernment organization membership is committed to eradicating feral hogs from Missouri because of their ecological impact, agricultural damage, and disease threats. Our objectives were to characterize the current distribution of feral hogs in Missouri, particularly as they relate to domestic swine facilities, and to determine prevalence and distribution of feral hogs with antibodies against selected major livestock, wildlife, and human diseases.

Methods

We recorded feral hog sightings throughout Missouri from 2000 to 2005. To accomplish this, we posted signs at all public land access points and in agency offices that were signatories of the MFSTF soliciting the public to report feral hog sightings. Additionally, we asked the public to report feral hog tracks, scats, and rubs (following Barrett and Birminghamm, 1994) they encountered during their activities on both private and public lands, specifically noting direct observations of hogs, tracks, scats, and rubs. We verified these sightings and reports of feral hog sign through subsequent site visits by Wildlife Services wildlife biologists who found similar observations. Feral hog scat and rubs are distinctive, and we had no difficulty distinguishing them from those of other species. Additionally, we queried all Missouri Wildlife Services and Missouri Department of Conservation biologists for new feral hog sightings annually. Lastly, we investigated reports of feral hog harvests and obtained geo-referenced locations of harvest sites.

We imported all feral hog sightings (n = 165) into a geographic information system using ArcGIS 9.0 (Environmental Systems Research Institute, 1999). We overlaid sighting locations onto a coverage map of Missouri, with public lands and locations of domestic hog facilities included as layers. Additionally, we generated random points (n = 165) within Missouri using the Animal Movement extension (Hooge and Eichenlaub 1997) of ARCVIEW® (Environmental Systems Research Institute 1999). Furthermore, we generated distances between locations of feral hog sightings and random locations within Missouri to domestic swine facilities and public land using the Nearest Features extension (Jenness 2004) of ARCVIEW. We determined differences between observed and random observations for the above mentioned distances using pooled t-tests. We considered statistical significance at α= 0.05 and reported means ± SE.

We collected and analyzed blood samples from feral hogs removed from 1993 to 2005. Additionally, federal and state employees, private landowners, and hunters began collecting blood samples opportunistically in 2002. We made blood collection kits available free of charge to private landowners and hunters through USDA/APHIS/Wildlife Services and Missouri Department of Conservation personnel. Kits contained the necessary supplies and instructions on how to collect, preserve, and ship blood samples to the laboratory.

Agency personnel, private landowners, and hunters submitted whole blood to the Missouri Department of Agriculture Diagnostic Laboratory (MDADL) in Jefferson City. Upon arrival, we centrifuged blood samples and serum was removed and partitioned into separate cryovials. We stored aliquots at -20° C until they were tested for the presence of antibodies. Pseudorabies virus and swine brucellosis diagnostics were performed at the MDADL. We submitted separate aliquots to the USDA Agricultural Research Service laboratory in Plum Island, New York, for classical swine fever diagnostics and the U.S. Centers for Disease Control and Prevention in Atlanta, Georgia, for tularemia diagnostics.

An enzyme-linked immunosorbent assay (ELISA) was used to detect antibodies against PRV (IDEXX Laboratories, Inc., Westbrook, Maine). Antibody presence against PRV was further validated with a latex agglutination test (Viral Antigens, Inc., Memphis, Tennessee). The buffered acidified plate agglutination test (IDEXX Laboratories, Inc., Westbrook, Maine) and particle concentration fluorescence immunoassay (IDEXX Laboratories, Inc., Westbrook, Maine) were used detect antibodies against *Brucella suis*, the causative agent of swine brucellosis. An ELISA was used to determine presence of antibodies against classical swine fever (Shannon et al. 1993). The microscopic agglutination test described by Gese et al. (1997) for detecting antibodies against *Francisella tularensis*, the causative agent of tularemia, was used with a titer of ≥1:128 considered positive. The low occurrence of disease-positive feral hogs did not lend itself to meaningful statistical comparisons. Consequently, we report descriptive data.

Results

From 2000 to 2005, we verified 115 feral hog sightings (both individuals and groups) that were reported by the public. We recorded an additional 50 observations of feral hogs by agency personnel. Many of these sightings occurred on or in close proximity to public land (Figure 1) and may involve illegal releases for hunting opportunities. For example, we found that the distances between hog sighting locations to the nearest public land ($\bar{x}$ = 1,266 ± 173 m) and distances between hog sightings and random points within Missouri ($\bar{x}$ = 5,027 ± 292 m; Figure 1) were significantly different (t = 11.09, P <0.001). Additionally, we found that locations of hog sightings were significantly farther (t = 4.67, P <

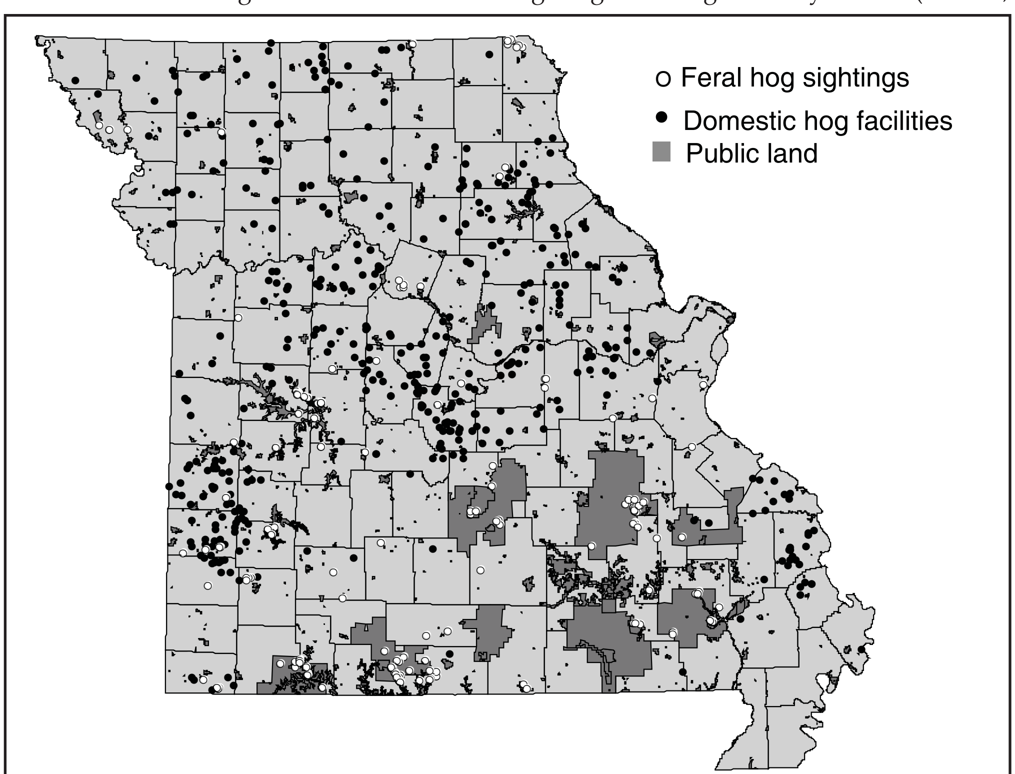

FIGURE 1. Feral hog sitings in Missouri, individual and groups, from 2000 to 2005.

0.001) from domestic hog facilities ($\bar{x}$ = 27,867 ± 1,232 m) than random points within Missouri ($\bar{x}$ = 19,475 ± 1,310 m).

We distributed >900 blood sampling kits to private landowners and hunters from 2002–2005. Our return rates were low, but were combined with sera samples collected by Missouri Wildlife Services personnel from 1993 to 2005, yielding samples from 321 feral hogs. Counties where we analyzed >10 samples included McDonald (11), Reynolds (21), Barry (23), and Pulaski (82). We found no evidence of antibodies against PRV or classical swine fever (Table 1). We found 1 feral hog to have antibodies against brucellosis (0.3% prevalence) and 1 feral hog to have antibodies against tularemia (1.3% prevalence). The brucellosis-positive hog was sampled in 1999 from Cole County in central Missouri, and the tularemia-positive hog was sampled in 2005 from Barry County in southwestern Missouri.

Table 1. Serologic test results for antibodies against selected diseases in Missouri feral hogs from 1993–2005.

Disease	Test method(s)[a]	Sera tested	Positive	
			Number	%
Pseudorabies virus	ELISA, latex agglutination	321	0	0.0
Swine brucellosis	BAPA, PCFIA	321	1[b]	0.3
Tularemia	Microscopic agglutination	80	1[c]	1.3
Classical swine fever	ELISA	321	0	0.0

[a] See text for description of tests.

[b] Positive animal from Cole County in 1999.

[c] Positive animal from Barry County in 2005

Discussion

State and federal agency personnel in Missouri have successfully reduced feral hog herds on their respective properties (Hartin 2006); however, many of the recent sightings have occurred on private land. Recently-appropriated federal funds will provide much needed resources to target herds on private land in Gentry, Shelby, Caldwell, Holt, Nodaway, Clark, Barton, Vernon, and Dade counties. At the same time, surveillance for brucellosis and PRV in Oregon County will receive priority because the last PRV-infected feral hogs were found there in the 1990s. Feral hog populations in Howell, McDonald, Barry, Stone, and Taney counties need continued disease surveillance because of their proximity to federal lands where illegal releases are thought to occur.

Our observed lack of proximity between domestic hog facilities and feral hog sightings may be misleading. The Missouri Department of Agriculture does not keep location records for transitional hog facilities, and, therefore, they were not represented in the analyses or in Figure 1. Transitional facilities are those that maintain domestic hogs in outdoor pens or pastures. Consequently, they are the facilities that are most at risk of feral hogs interacting with their domestic swine and exposing them to diseases through common transmission routes.

Missouri is fortunate in that only 1 case of brucellosis and no cases of PRV have been found in feral hogs since 1993. Pseudorabies is of considerable concern to hog producers worldwide because of the economic losses associated with reduced productivity and piglet fatalities. The USDA initiated a nationwide PRV-eradication program in 1989, and the disease has been eliminated from United States domestic hog herds; however, PRV has been reported in feral hogs from ≥10 states (Müller et al. 2000). The persistence of infection in feral hog populations (Corn et al. 2004), coupled with feral hog range expanse, has created the potential for reintroduction of the virus to domestic herds.

Annual pork sales in the United States exceed $1 billion, with retail sales exceeding $34 billion (Witmer et al. 2003). There is concern relating to the role feral hogs could pose to the pork industry as a reservoir for disease (Seward et al. 2004).

Wildlife managers and agriculture specialists are concerned about expanding populations of feral hogs (Adkins and Harveson 2007). As feral hog populations expand either through illegal translocations or reproduction, the damage to agriculture, environmental degradation, competition with native wildlife, and the threat of diseases are increased.

Feral hogs cause habitat degradation (Engeman et al. 2007*a*, 2007*b*) pose a serious threat to livestock, and hinder our ability to eradicate several important diseases of livestock in the United States. Disease outbreaks involving risk to livestock, humans, and other wildlife are high profile, high priority situations that typically receive substantial attention and funding at both the state and federal levels (Conover and Vail 2007). Emergency funds are often made available for several years but may quickly disappear when another disease suddenly appears and takes priority. Because of the wide occurrence of feral hog populations in the United States and the technical challenges posed by feral hog management, it is important for federal agencies to establish priorities for which states to address first in this effort and how to divide the limited resources available to conduct activities (Mackey 1991). Education efforts and collection instructions should emphasize the importance of timely sample collection and proper handling to increase the proportion of useable blood samples from these sources.

Although the goal of the MFSTF is the elimination of feral hogs from the state, a more effective approach, given limited resources, may be to eradicate diseases found within the feral hog population. This could be achieved by identifying hog populations carrying diseases and targeting control efforts within these populations. This strategy would not require the removal of all feral hogs in Missouri; however, it does not address the other conflicts (e.g., agricultural and ecological damage) caused by feral hogs.

The agencies and organizations involved in the MFSTF have prioritized needs to manage feral hogs in Missouri. The need for consistent funding at an adequate level to support ≥3 field personnel is imperative to control the expansion and increase of feral hog populations. Continued disease surveillance is critical to be able to react to any diseases that are found and eliminate them before they become established in the feral hog populations. Research on better control methods and baits used to lure feral hogs are also needed, as is better communication with the public about the importance of feral hog management (Rollins et al. 2007). For Missouri, it is critical that the multiagency task force continue to meet and address the feral hog issue because it affects all areas of public health, agriculture, conservation, and natural resources.

Acknowledgments

Financial and logistical support was provided by the USDA/APHIS/Wildlife Services, the Missouri Department of Conservation, and the Department of Fisheries and Wildlife Sciences at the University of Missouri—Columbia. We are indebted to Missouri Wildlife Services personnel, especially D. W. McMurtry, S. Radford, and T. A. Hutton. We are grateful to many Missourians who kindly reported feral hog sightings and assisted with tissue collection. Editorial comments on earlier drafts of this manuscript were generously provided by R. G. McLean and D. B. Long.

Literature cited

Adkins, R. N., and L. A. Harveson. 2007. Demographic and spatial characteristics of feral hogs in the Chihuahuan Desert, Texas. Human–Wildlife Conflicts 1:152–169.

Barrett, R. H., and G. H. Birmingham. 1994. Wild pigs. Pages D-65–D-70 *in* S. E. Hygnstrom, R. M. Timm, and G. E. Larson, editors. Prevention and control of wildlife damage. University of Nebraska—Lincoln, Lincoln, Nebraska, USA.

Becker, H. N., R. C. Belden, T. Breault, M. J. Burridge, W. B. Frankenberger, and P. Nicoletti. 1978. Brucellosis in feral swine in Florida. Journal of the American Veterinary Medical Association 173:1181–1182.

Conover, M. R., and R. M. Vail. 2007. In the news. Human–Wildlife Conflicts 1:3–4.

Corn, J. L., D. E. Stallknecht, N. M. Mechlin, M. P. Luttrell, and J. R. Fischer. 2004. Persistence of pseudorabies virus in feral swine populations. Journal of Wildlife Diseases 40:307–310.

Corn, J. L., P. K. Swiderek, B. O. Blackburn, G. A. Erickson, A. B. Thiermann, and V. F. Nettles. 1986. Survey of selected diseases in wild swine in Texas. Journal of the American Veterinary Medical Association 189:1029–1032.

Engeman, R. M, B. U. Constantin, S. A. Shwiff, H.

T. Smith, J. Woolard, J. Allen, and J. Dunlap. 2007*a*. Adaptive and economic management methods for feral hog control in Florida. Human–Wildlife Conflicts 1:178–185.

Engeman, R. M., J. Woolard, H. T. Smith, J. Bourassa, B. U. Constantin, and D. Griffin. 2007*b*. An extraordinary patch of feral swine damage in Florida before and after initiating hog removal. Human–Wildlife Conflicts 1:271–275.

Environmental Systems Research Institute. 1999. ARCVIEW, version 3.2. Environmental Systems Research Institute, Redlands, California, USA.

Gese, E. M., R. D. Schultz, M. R. Johnson, E. S. Williams, R. L. Crabtree, and R. L. Ruff. 1997. Serological survey for diseases in free-ranging coyotes (*Canis latrans*) in Yellowstone National Park, Wyoming. Journal of Wildlife Diseases 33:47–56.

Hartin, R. E. 2006. Feral hogs—status and distribution in Missouri. Thesis, University of Missouri—Columbia, Columbia, Missouri, USA.

Hooge, P. N., and B. Eichenlaub. 1997. Animal movement extension to ARCVIEW, version 1.1. U.S. Geological Survey, Anchorage, Alaska, USA.

Jenness, J. 2004. Nearest features extension for ARCVIEW, version 3.8a. Jenness Enterprises, Flagstaff, Arizona, USA.

Kaller, M. D., J. D. Hudson III, E. C. Archberger, and W. E. Kelso. 2007. Feral hog research in western Louisiana: expanding populations and unforeseen consequences. Human–Wildlife Conflicts 1:168–177.

Mackey, W. 1991. The implications of the importation of wild hogs on the northern United States. Proceedings Annual Meeting of the United States Animal Health Association 94:401–403.

Müller, T., F. J. Conraths, and E. C. Hahn. 2000. Pseudorabies virus infection (Aujeszky's disease) in wild swine. Infectious Disease Review 2:27–34.

Rollins, D., B. J. Higginbotham, K. A. Cearley, and R. N. Wilkins. 2007. Appreciating feral hogs: extension education for diverse stakeholders in Texas. Human–Wildlife Conflicts 1:192–180.

Samuel, W. M., M. J. Pybus, and A. A. Kocan. 2001. Parasitic diseases of wild mammals. Iowa State University Press, Ames, Iowa, USA.

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.

Shannon, A. D., C. Morrissy, S. G. Mackintosh, and H. A. Westbury. 1993. Detection of hog cholera virus antigens in experimentally-infected pigs using an antigen-capture ELISA. Veterinary Microbiology 34:233–248.

Williams, E. S., and I. K. Barker. 2001. Infectious diseases of wild animals. Iowa State University Press, Ames, Iowa, USA.

Witmer, G. W., R. B. Sanders, and A. C. Taft. 2003. Feral swine—are they a disease threat to livestock in the United States? Proceedings of the Wildlife Damage Management Conference 10:316–325.

Wood, G. W., J. B. Hendricks, and D. E. Goodman. 1976. Brucellosis in feral swine. Journal of Wildlife Diseases 12:579–582.

R. Edwin Hartin (photo) is state director of the Missouri and Iowa USDA/APHIS Wildlife Services program. His professional interests include implementing effective, cost-efficient, humane, and socially acceptable techniques to resolve human-wildlife conflicts.

Mark R. Ryan is director of the School of Natural Resources at the University of Missouri-Columbia. His research interests include endangered species, avian ecology, conservation biology, population ecology, and grassland and wetland ecosystem management.

Tyler A. Campbell is a research wildlife biologist at the Wildlife Services' National Wildlife Research Center-Texas Field Station. His research interests include wildlife ecology and management.