

Evaluation of Feral Swine-Specific Feeder Systems

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Feral swine (*Sus scrofa*) have been introduced across many portions of the globe, including rangeland ecosystems of the United States. Feral swine populations are expanding because of their adaptability, high reproductive potential, and because they are (accidentally and intentionally) released by humans. Today, feral swine are the most abundant exotic ungulate in the United States.¹

Rangeland ecosystems are impacted by feral swine primarily through soil disturbance caused by rooting activities. Within these systems, natural disturbances (e.g., burrowing, grazing by native animals, and periodic fire) generally increase or maintain species diversity.² However, rooting by feral swine often occurs at intensities and frequencies that do not mimic natural disturbances and can have negative impacts, such as disseminating exotic plant species and reducing native plant species diversity.³

Feral swine damage to livestock enterprises within rangeland ecosystems is direct (e.g., predation) and indirect (e.g., destruction of fencing and disease transmission) and both cause substantial economic losses.⁴ In Australia, predation on lambs often is widespread and is influenced by feral swine density.^{5,6} Feral swine predation on livestock is

also a problem in the United States in localized regions.⁷ Furthermore, Seward et al. (2004) recommend close monitoring of livestock and confining preparturition animals prior to calving and lambing to minimize risks of predation by feral swine.⁴

Tools available to control feral swine damage have not been universally successful.⁸ New methods, such as fertility control agents, vaccines, or toxicants, are needed and will require an oral delivery system for effective administration to feral swine populations.¹ Prior investigations of baits intended for pharmaceutical delivery to feral swine in the United States have found that the concept is feasible,⁹ but that there are challenges in developing species-specific baits for feral swine.^{10,11} These studies have led to the creation of relatively inexpensive prototypes of nontarget exclusion feeder systems (NEFS) for feral swine. None of these feeder systems has been evaluated in the United States.

Our overall objective was to evaluate candidate NEFS for feral swine as a means to deliver baits containing pharmaceuticals. Our specific objective was to compare feral swine and nontarget animal consumption events at three different feeder systems in a rangeland ecosystem of southern Texas. Given the successes of the Boar-Operated-System (BOS™) feeder in the United Kingdom,¹² we hypothesized that this unit would be specific to feral swine in southern Texas.

Methods

Our study was conducted on the Rob and Bessie Welder Wildlife Foundation (WWF; lat 28°06'N, long 97°22'W) in San Patricio County, Texas. The WWF is approximately 3,100 ha and receives an average of 79 cm of rainfall annually. The WWF is bordered to the north by the Aransas River, the west by US Highway 77, and the south and east by private rangeland. Overstory vegetation consists of huisache (*Acacia farnesiana*), honey mesquite (*Prosopis glandulosa*), live oak (*Quercus virginiana*), cedar elm (*Ulmus crassifolia*), net-leaved hackberry (*Celtis reticulata*), anaqua (*Ehretia anacua*), and muscadine (*Vitis rotundifolia*). Nontarget species of interest on the WWF are raccoons (*Procyon lotor*), white-tailed deer (*Odocoileus virginianus*), and collared peccaries (*Pecari tajacu*).



Feral swine on the Rob and Bessie Welder Wildlife Foundation.

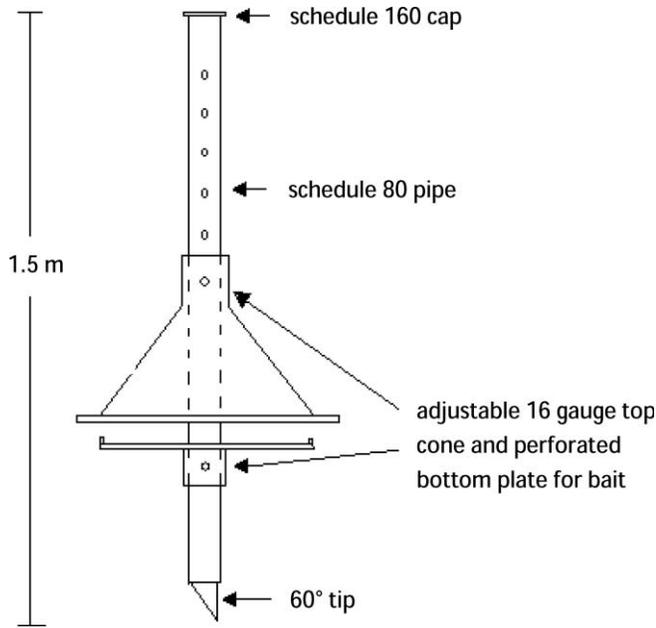


Figure 1. Diagram of the boar operated system (BOS) feeder prototype used during November–December 2008 in San Patricio County, Texas.

We used three NEFS prototypes during this study. The first prototype consisted of a model developed by the Food and Environment Research Agency in the United Kingdom, known as the BOS (Fig. 1).¹² The second prototype, or nontarget exclusion device (NED), consisted of a wooden feeder system with a spring-loaded push-up lid (Fig. 2). The third prototype, or bucket, consisted of a plastic feeder system with a spring-loaded push-up lid (Fig. 3). We baited feeder systems with 200 g whole kernel corn and six polymer fishmeal baits (Bait-Tek Inc., Orange, TX). We used fishmeal baits that were 2×3×5 cm and were open-ended and hollow for insertion of a pharmaceutical agent. We used fishmeal bait to increase attractiveness to omnivorous

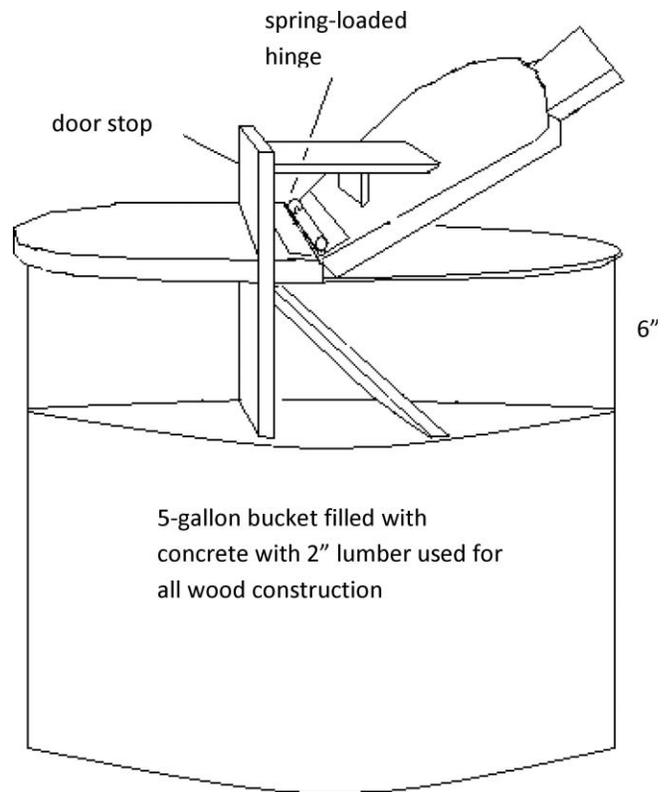


Figure 3. Diagram of the bucket feeder prototype used during November 2008 (during a proof-of-concept period) in San Patricio County, Texas.

nontarget animals. We presented fishmeal baits to captive feral swine to ensure their consumption prior to their use in our trial.¹³

The BOS feeder was fabricated from metal and rested on a lubricated mast that was hammered into the ground. The base plate where we placed bait was positioned 30 cm from the ground and was fixed to the mast. The conical lid of the BOS feeder was larger than the base plate and sat firmly on

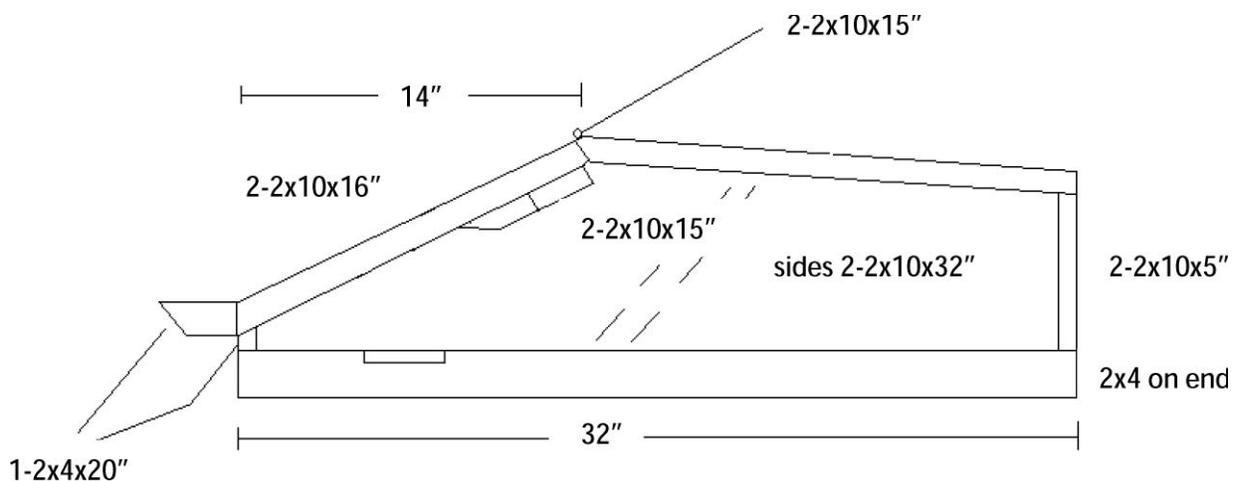


Figure 2. Diagram of the nontarget exclusion device (NED) feeder prototype used during November–December 2008 in San Patricio County, Texas.

the base plate when closed (Fig. 1). We constructed the NED feeder from treated pine 2×10 finished lumber. We built the NED feeder to an initial lift height of 13 cm (Fig. 2). We constructed the bucket feeder system with a treated pine 2×10 finished lumber top attached to a 22.7-L bucket filled with 27.2 kg of 5,000 psi concrete. We positioned the lid such that half could be lifted for bait access. On the bucket feeder, we set the wooden extension that allows for feeder system usage to 35 cm above the ground (Fig. 3). All three types of feeder systems required a lifting motion for bait access. The NED and bucket feeders were constructed to keep the bait at the front of the system. We measured the weight needed to lift the lid for bait access with a spring scale (Model 80020, PESOLA AG, Baar, Switzerland). The lift weight was 12–15 kg for the BOS, 3–4 kg for the NED, and 0.5–1 kg for the bucket feeders. We anchored the NED and bucket feeders to vegetation or fence posts to keep feral swine from turning systems over, but the BOS feeders did not need additional anchoring after we hammered them into the ground (~60 cm).

We collected proof-of-concept digital image data on the NED and bucket feeders to determine performance in a captive setting prior to our field trial. Based on these data, and information from limited field deployments of the bucket feeder, we did not include this system in our trial due to heavy nontarget use when systems were activated (i.e., lids were closed).

We used 10 BOS feeders and 10 NED feeders during our trial. We selected 10 sites ≥1 km apart in areas of high feral swine activity. At each of the 10 sites we placed one BOS feeder and one NED feeder 30 m apart. We monitored each feeder system for 4 weeks (during November to December 2008) using camera traps (Silent Image Professional and Rapidfire Editions, Reconyx, Holmen, WI). We operated camera systems ($n=20$) at their highest sensitivity setting and programmed cameras to maintain a 0.5-second delay. We set up camera systems 3–5 m from feeder systems and used vegetation or artificial structures (e.g., fence posts) as supports. During the first 14 days of the trial we tied all feeder system lids slightly open (i.e., 10 cm) to allow most animals access to the bait. During the second 14 days of the trial we untied and activated feeder system lids (i.e., lids were closed).

We revisited feeder systems daily from 8 AM to 12 noon to check baits and cameras, recording the presence or absence of bait and bait condition. Additionally, at this time we downloaded digital images that were stored. If bait was removed from the feeder system, we then replaced the bait, ensuring that six fishmeal baits and 200 g of corn were available at the beginning of each 24-hour period. If fishmeal baits were not removed after seven nights, we then replaced baits.

We quantified feeder system usage as visitation and bait removal (i.e., consumption events) by species through digital image analyses. We defined visitation as the total number of

individuals within 1 m of baits prior to and including bait removal. When possible, we used unique physical characteristics (e.g., body size, pelage color, antler pattern) to identify individuals. To reduce inflated visitation estimates, we did not count individuals that made repeated visits within a 30-minute period. We considered such events to be one visit. We recorded digital image data into one of three bait removal categories: definitely removed by species (images in which the bait is in the mouth of an animal or a series of images 5 minutes or less apart in which only the species of record was observed and the bait was removed); possibly removed by species; and removed by unknown species. If all bait was removed from a feeder system within a 24-hour period, we did not continue to count usage within that period. We report consumption events and performed statistical analyses on the percent change in consumption pre- and postfeeder system activation by feeder type and species. For these models, we used paired t -tests (PROC UNIVARIATE, SAS Institute, Inc., Cary, NC).

Results

We recorded more than 400,000 digital images during November and December, 2008. We found removal rates for BOS and NED feeder systems were 96% and 95% during the preactivation period and 45% and 90% while feeder systems were activated, respectively. Both the corn and fishmeal baits were consumed by feral swine and raccoons, the primary nontarget species observed during our trial. Overall (both feeder systems combined), we found bait removal rates of 54% by raccoons, 32% by feral swine, 10% by white-tailed deer, and 4% by collared peccaries. For BOS feeders during preactivation, the mean bait removal rates were 36% by raccoons, 34% by feral swine, 21% by white-tailed deer, and 9% by collared peccaries. Once BOS feeders were activated, 100% of the baits were removed by feral swine. For NED feeders during preactivation, the mean bait removal rates were 64% by raccoons, 23% by feral swine, 2% by white-tailed deer, and 11% by collared peccaries. Once NED feeders were activated, removal rates were 70% by raccoons, 20% by feral swine, 0% by white-tailed deer, and 10% by collared peccaries. The bucket feeder system was used by all species immediately upon activation and was omitted from further experimentation.

Following activation of BOS feeders, bait removal decreased 48% for feral swine and 100% for all other species (Fig. 4). Following activation of the NED feeders, bait removal decreased 19%, 28%, 100%, and 100% for raccoons, feral swine, white-tailed deer, and collared peccaries, respectively. Comparing feeder system performance by species we found no differences in feral swine usage between types following activation ($t_7=-1.231$, $P=0.258$). Raccoons used the NED feeder more than the BOS feeder following activation ($t_9=-4.75$, $P=0.001$). Other wildlife that visited the BOS and NED feeders in low numbers were southern plains woodrat (*Neotoma micropus*), eastern cottontail (*Sylvilagus*



Boar-Operated-System during the pre-activation period on the Rob and Bessie Welder Wildlife Foundation.

floridanus), nine-banded armadillo (*Dasyus novemcinctus*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), and various avian species. We found no interest in either feeder system by cattle, which were present throughout the trial.

Discussion

Researchers within rangeland ecosystems of Pakistan have used simple feeder systems similar to our NED feeders to deliver the toxicant coumatetralyl to feral swine with success.¹⁴ Additionally, an inexpensive feral piglet-specific feeder system has been evaluated in rangeland ecosystems of south-central Spain to increase bait uptake.¹⁵ Our simple and inexpensive bucket and NED feeders did not perform as well as these systems. We believe that this discrepancy is due to the presence of raccoons, a persistent and resourceful omnivorous nontarget species that occurs throughout the United States. Similarly, raccoons have proven to be a formidable nontarget species in other studies testing feral swine-specific delivery systems in rangelands of southern Texas.¹¹ However, the performance of the BOS feeder in our trial was excellent and consistent with our hypothesis that bait removal with this system would be specific to feral swine.

All three feeder systems used in our trial exploited the rooting behavior of feral swine. Additionally, we observed variation in feral swine foraging at feeder systems. When feral swine used the BOS feeder, they tended to pick up the lid, consume a small amount of bait, and drop the lid again. However, when feral swine used the NED feeder, they tended to pick up the lid, let the lid rest on their back, and consume all the bait in one feeding bout. These observations account for the lower number of consumption events at the NED feeders and greater removal rate by feral swine compared to BOS feeders. We observed that raccoons typically consumed bait for a brief moment, and then

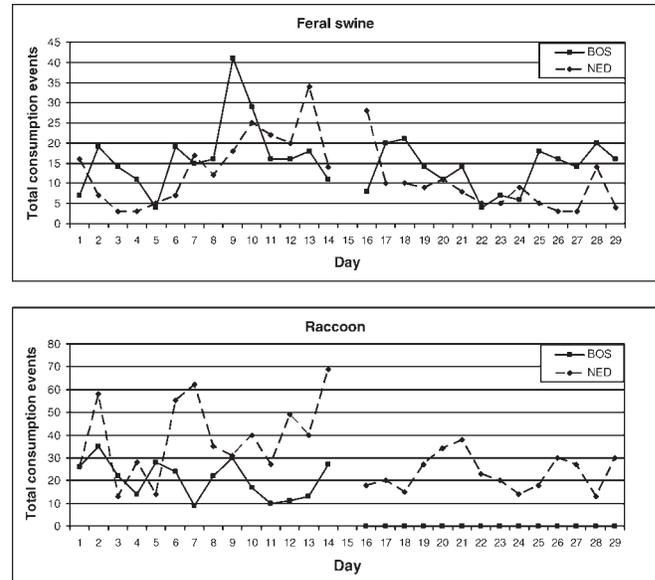


Figure 4. Total consumption events by day for feral swine (top) and raccoons (bottom) for the BOS and NED feeder systems. Both feeder systems were activated on day 15, during November–December 2008 in San Patricio County, Texas.

quickly vacated the NED. This strategy might be related to predator avoidance.

Differences between feeders might explain the differences in our observations while systems were activated. The BOS feeder was accessible from 360°, whereas the NED feeder was accessible from only the front 90° (Figs. 1 and 2). We observed that this confused feral swine and that they often would leave the NED feeder site or try to flip over or push the system to obtain bait. We recommend that lids of NED feeders be modified to extend an overhang edge to facilitate lid lifting around three sides of the lid rather than only at the front of the system. Another difference in feeders was the lid height when the feeder was activated. The BOS feeder was adjustable and set at 30 cm, whereas the NED feeder was permanently set at 13 cm. The lower lid height of the NED feeder possibly restricted access by larger swine and facilitated access by smaller nontarget species. An additional factor that influenced access to the feeders was the weight of the lid. The BOS feeder required animals to lift 12–15 kg, whereas the NED feeder required animals to lift 3–4 kg. We believe that lift effort was the most important factor allowing nontarget species access to NED feeders and restricting access to BOS feeders. For example, because the weight of an adult raccoon in southern Texas ranges from 5 kg to 11 kg, these animals would have to lift up to twice their body weight to gain access to the BOS feeder. We recommend that lids of NED feeders be modified by adding weight to the lid, thereby increasing the amount of effort required to lift the lid.

One potential downside to the BOS feeder is cost. Each BOS feeder cost approximately \$400 to fabricate, whereas



Non-target exclusion device during the pre-activation period on the Rob and Bessie Welder Wildlife Foundation.

the NED feeder and bucket feeder cost approximately \$50 and \$20/system, respectively. A BOS feeder could be constructed by a metal fabricator for relatively little cost, but to duplicate the BOS feeder design without any materials or knowledge of metalwork would be challenging. Metal used in the BOS feeders typically is sold in large, rather than small, pieces and skilled welders cost \$40–\$60/hour, with each system taking approximately 5–10 hours to construct. Large orders involving tens of BOS feeders would be less expensive than small or individual orders. Because the BOS feeders are constructed from metal, they have a long life expectancy and are virtually unbreakable, which is good, considering the destructive habits of feral swine. Consequently, there is potential for initial costs to be recouped over time with continuous use, perhaps in a cooperative arrangement among landowners.

Past research has suggested using diel activity patterns as a means to create a more species-specific delivery system for omnivores. This concept has not proven useful for feral swine because these animals primarily are nocturnal with crepuscular peaks, similar to most nontarget species occurring in this region. Consequently, applying baits to feeder systems only during periods of peak feral swine activity in hopes of only delivering baits to feral swine is not a plausible strategy.

Implications

In five years of performing trials on feral swine-specific delivery systems, the BOS feeder marks the first system we have identified to meet our needs. Consequently, we recommend further trials with the BOS feeders within rangeland and other ecosystems of the United States. Of particular interest are ecosystems that contain sympatric feral swine and black bears (*Ursus americanus*). Furthermore, future trials should be related to optimum BOS feeder density and positioning, time until feral swine discovery and use, and feral swine use at the population level. Additionally,

given the inexpensive and simple characteristics of the NED feeder, we recommend further evaluations of this system employing the abovementioned modifications. Lastly, a bait that is highly attractive to feral swine and is capable of housing and delivering pharmaceuticals needs to be further developed.

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References

1. SWEENEY, J. R., J. M. SWEENEY, AND S. W. SWEENEY. 2003. Feral Hog *Sus scrofa*. In: G. A. Feldhamer, B. C. Thompson, and J. A. Chapman [EDS.]. Wild mammals of North America: biology, management, and conservation. 2nd ed. Baltimore, MD, USA: Johns Hopkins University Press. p. 1164–1179.
2. COLLINS, S. L., AND S. C. BARBER. 1985. Effects of disturbance on diversity in mixed-grass prairie. *Vegetatio* 64:87–94.
3. TIERNEY, T. A., AND J. H. CUSHMAN. 2006. Temporal changes in native and exotic vegetation and soil characteristics following disturbances by feral pigs in a California grassland. *Biological Invasions* 8:1073–1089.
4. 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.
5. CHOQUENOT, D., B. LUKINS, AND G. CURRAN. 1997. Assessing lamb predation by feral pigs in Australia's semi-arid rangelands. *Journal of Applied Ecology* 34:1445–1454.
6. PLANT, J. W., R. MARCHANT, T. D. MITCHELL, AND J. R. GILES. 1978. Neonatal lamb losses due to feral pig predation. *Australian Veterinary Journal* 54:426–429.
7. BEACH, R. 1993. Depredation problems involving feral hogs. In: C. W. Hanselka and J. F. Cadenhead [EDS.]. Feral swine: a compendium for resource managers. Kerrville, TX, USA: Texas Agricultural Extension Service. p. 67–75.
8. CAMPBELL, T. A., AND D. B. LONG. 2009. Feral swine damage and damage management in forested ecosystems. *Forest Ecology and Management* 257:2319–2326.
9. 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.
10. CAMPBELL, T. A., S. J. LAPIDGE, AND D. B. LONG. 2006. Using baits to deliver pharmaceuticals to feral swine in southern Texas. *Wildlife Society Bulletin* 34:1184–1189.

11. CAMPBELL, T. A., AND D. B. LONG. 2007. Species-specific visitation and removal of baits for delivery of pharmaceuticals to feral swine. *Journal of Wildlife Diseases* 43:485–491.
12. MASSEI, G., J. COATS, R. QUY, K. STORER, AND D. P. COWAN. 2010. The boar-operated-system: a novel method to deliver baits to wild pigs. *Journal of Wildlife Management* 74:333–336.
13. REIDY, M. M., T. A. CAMPBELL, AND D. G. HEWITT. 2008. Tetracycline as a biological marker for mark–recapture analysis of feral pigs. *Proceedings of the Vertebrate Pest Conference* 23: 210–212.
14. KHAN, M. H. 1991. Field evaluation of blood anticoagulants for the control of wild boar, and social behaviour of these animals. Second Quarterly Report on Wild Boar Research Project. United States Agency for International Development Mission to Pakistan. Project Number 0491-C 004/87 (I). Faisalabad, Pakistan: University of Agriculture. 50 p.
15. BALLESTEROS, C., R. CARRASCO-GARCÍA, J. VICENTE, J. CARRASCO, A. LASAGNA, J. DE LA FUENTE, AND C. GORTÁZAR. 2009. Selective piglet feeders improve age-related bait specificity and uptake rate in overabundant Eurasian wild boar populations. *Wildlife Research* 36:203–212.

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