2012

# Preliminary Assessment of the HogHopper™ for Excluding Non-Target Wildlife

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**Abstract:** Feral swine populations are expanding throughout the U.S., where they are causing increasing amounts of damage to agriculture, natural resources, and property and threaten human health and safety. Methods to control feral swine damage in the U.S. consist of integrated fencing, trapping, snaring, and shooting (including hunting with dogs) efforts. New methods that are being developed to control feral swine damage include toxicants and fertility control agents. For these emerging technologies to be effective at the population level, they must function through oral routes of delivery. Concurrent to the development of orally-delivered actives, a cost-effective system that delivers biologics to feral swine while restricting access to non-target wildlife, needs to be developed. Our objectives are to 1) describe historical efforts to develop a feral swine-specific oral delivery system in the U.S., 2) present preliminary findings from an ongoing collaborative evaluation of the Australian-made HogHopper™, and 3) outline future opportunities in developing a feral swine-specific oral delivery system. While there is a real need for a feral swine-specific oral delivery system, presently there is no universally effective system suitable for all applications and field scenarios. Each system has its advantages and disadvantages that must be assessed within its management context.

**Key Words:** bait, Boar-Operated-System, feral swine, HogHopper™, oral delivery system, *Sus scrofa*, swine

**Proc. 25th Vertebr. Pest Conf.** (R. M. Timm, Ed.)
**Published at Univ. of Calif., Davis. 2012**. Pp. 333-336.

## INTRODUCTION

Feral swine (*Sus scrofa*) populations are expanding throughout the U.S., where they are causing increasing amounts of damage to agriculture, natural resources, and property and threaten human health and safety (Campbell and Long 2009a). Populations of feral swine are reported to occur in 46 states (Mayer 2011), where damage can be extensive. For example, feral swine damage to agricultural interests in Texas alone is estimated at $52 million annually (Higginbotham et al. 2008). New methods to control feral swine damage are needed.

Current methods to control feral swine damage in the U.S. consist of integrated fencing, trapping, snaring, and shooting (including hunting with dogs) efforts; each method has associated advantages and disadvantages (Campbell and Long 2009a). New methods that are being developed to control feral swine damage include toxicants (Cowled et al. 2008) and fertility control agents (Campbell et al. 2010, Sanders et al. 2011), with the latter being developed as a tool to assist in emergency disease epidemics. For either of these emerging technologies to be effective at the population level, they must function through oral routes of delivery (Campbell et al. 2010). Concurrent to the development of orally-delivered actives, a cost-effective system that delivers biologics to feral swine while restricting access to non-target wildlife needs to be developed, because most candidate toxicants and fertility control agents are not feral swine-specific (Campbell et al. 2010, Lapidge et al. 2011).

Our objectives are to 1) describe historical efforts to develop a feral swine-specific oral delivery system in the U.S.; 2) present preliminary findings from an ongoing collaborative evaluation of the Australian-made HogHopper™, a device intended to deliver HOG-GONE® toxic baits to feral swine; and 3) outline future opportunities in developing a feral swine-specific oral delivery system.

## FERAL SWINE ORAL DELIVERY SYSTEMS RESEARCH IN THE U.S.

Efforts to develop an oral delivery system for feral swine in the U.S. has an abbreviated history compared with other species and other countries. For example, studies have been conducted in Australia that have evaluated efficacy of toxic baits for feral swine for more than 3 decades (Hone and Pedersen 1980). Early work in the U.S. on a feral swine oral delivery system was spawned from these and other successes demonstrated within oral rabies vaccination programs in the U.S. (Shwiff et al. 2008).

Two foundational studies were performed on Ossabaw Island, GA that investigated feral swine oral delivery systems (Fletcher et al. 1990, Kavanaugh and Linhart 2000). In the first study, researchers used polymer-bound fish meal baits with soured chicken mash attractant and biomarkers to determine bait and simulated vaccine uptake

(Fletcher et al. 1990). Investigators distributed 1,980 baits and found that 88% of baits were removed after 72 hours (Fletcher et al. 1990). Furthermore, researchers found that 95% of feral swine and 44% of raccoons (*Procyon lotor*) had consumed baits, leading to the conclusion that oral vaccine delivery to feral swine was feasible (Fletcher et al. 1990). In the second study, investigators compared feral swine visitation and bait removal among 4 treatment baits consisting of 1) a polyurethane sleeve coated in a commercial corn-dog batter mix and deep fried, 2) polymer baits with grain-based dog food and corn meal, 3) polymer baits with grain-based dog food and fish meal, and 4) polymer-bound fish meal (Kavanaugh and Linhart 2000). Researchers found no differences in bait visitation and removal by feral swine and concluded that grain-based baits coated with attractants can be used to deliver oral biologics to feral swine (Kavanaugh and Linhart 2000).

In 2004, the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services program established the Texas Field Station through the National Wildlife Research Center (NWRC). One of the objectives of the field station's research project was to further develop oral delivery systems for feral swine. Field station scientists and collaborators immediately embarked on this endeavor, an effort that continues today through the feral swine research project at the NWRC Florida Field Station.

With the demonstrated effectiveness of PIGOUT® as an oral delivery system in Australia (Cowled et al. 2006a,b), NWRC researchers and collaborators began a series of field trials with non-toxic PIGOUT® in southern Texas. PIGOUT® is a grain-based bait with meat attractants and binding agents designed to deliver a lethal dose of sodium fluoroacetate to feral swine and is registered for use in Australia. In an initial study, investigators distributed 1,178 biomarked non-toxic PIGOUT® baits at a density of 68 baits/km$^2$ and found 90% of baits were removed after 72 hours (Campbell et al. 2006). However, 51% of baits were removed by raccoons, 22% were removed by feral swine, and 22% were removed by collared peccaries (*Tayassu tajacu*), suggesting that while bait consumption by feral swine was relatively high, further work was needed aimed at reducing non-target consumption (Campbell et al. 2006).

Four additional trials were conducted in southern Texas using non-toxic PIGOUT® (Campbell and Long 2007, 2009b). The first trial compared fish-flavored and vegetable-flavored PIGOUT® with and without a commercial raccoon repellent applied to the surface of the baits (Campbell and Long 2007). After 4 nights, between 93% and 98% of baits were removed and bait removal rates did not differ for feral swine, raccoons, and collared peccaries, but varied for coyotes (*Canis latrans*) and white-tailed deer (*Odocoileus virginianus*) (Campbell and Long 2007). The second trial compared fish-flavored and vegetable-flavored PIGOUT® distributed systematically at 200-m intervals and in clusters encompassing 5 m$^2$ (Campbell and Long 2007). Though researchers observed bait removal by a diverse suite of species including cattle, white-tailed deer, and eastern cottontail rabbits (*Sylvilagus floridanus*), fish-flavored baits that were distributed in a cluster were removed by feral swine at a rate greater than expected (Campbell and Long 2007). The third trial compared fish-flavored baits, vegetable-flavored baits, vegetable-flavored baits with a strawberry-flavored feed additive, fish-flavored baits with synthetic fermented egg attractant/repellent, and vegetable flavored baits with synthetic fermented egg attractant/repellent (Campbell and Long 2009b). The strawberry-flavored feed additive was previously identified as a candidate feral swine attractant (Campbell and Long 2008). Again, investigators found that many species removed PIGOUT® baits and that the addition of a strawberry-flavored feed additive and synthetic fermented egg attractant/repellent did not universally improve the feral swine-specific attributes of the delivery system (Campbell and Long 2009b). The fourth trial compared fish-flavored PIGOUT®, vegetable-flavored PIGOUT®, and vegetable-flavored PIGOUT® with a strawberry-flavored feed additive that were surface-deployed and buried to a depth of 10 cm (Campbell and Long 2009b). Researchers observed bait removal rates for surface-deployed baits to be between 68% and 75% and for buried baits to be between 60% and 72%, with no differences in removal rates for any species (Campbell and Long 2009b). Collectively, these trials demonstrated that a simple feral swine oral delivery system that uses unsecured baits is not appropriate for field application in the U.S. because of the high removal of baits by non-target species. Additional research into mechanical devices that exclude non-target species while delivering baits to feral swine was needed.

One such mechanical device is the Boar-Operated-System (BOS™), which was developed by the Food and Environment Research Agency in York, United Kingdom, to deliver baits containing pharmaceuticals to wild boar (Massei et al. 2010). The BOS™ is composed of 3 primary parts, including a main pole, moveable conical lid, and perforated base plate (Figure 1). An initial trial in southern Texas compared the feral swine-specific attributes of the BOS™ to two homemade oral delivery systems and found the BOS™ to be superior (Long et al. 2010). For example, for the BOS™ during a prebaiting period, mean bait removal rates were 36% by raccoons, 34% by feral swine, 21% by white-tailed deer, and 9% by collared peccaries; whereas once the BOS™ were activated, 100% of the baits were removed by feral swine (Long et al. 2010). These positive results led to two additional trials with the BOS™. During the first trial, researchers found 3 of 5 prebaited BOS™ were used by feral swine only and that the 5 BOS™ units that were not prebaited were not used by feral swine or other wildlife (Campbell et al. 2011). These findings illustrated the need for a prebaiting period to allow feral swine time to discover and learn how to

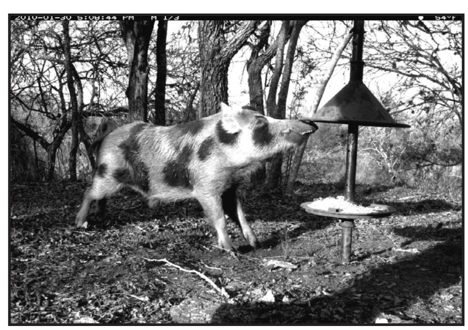

**Figure 1. The Boar-Operated-System (BOS™) developed by the Food and Environment Research Agency in York, United Kingdom.**


**Figure 2. The HogHopper™ developed by the Invasive Animals Cooperative Research Centre in Australia and Animal Control Technologies Australia.**

use the BOS™. During the second trial, investigators found that bait removal from the BOS™ was reduced by only 10% for feral swine when activated, whereas bait removal from the BOS™ by all other wildlife was reduced by 100% when activated (Campbell et al. 2011). Furthermore, 90% of the feral swine population had consumed baits delivered through the BOS™ and would have received a dose of the biologic, compared to only 13% of the raccoon population (Campbell et al. 2011).

Two desirable characteristics of a feral swine oral delivery system are lacking from the BOS™. First, while the BOS™ is inexpensive (approximately $400/unit) and could be reused on multiple baiting campaigns due to their durable construction, they require skilled metalworkers to fabricate the systems, which could limit their availability and application (Long et al. 2010). Second, the BOS™ has a limited bait capacity (10-15 baits, depending upon size of baits). This would require practitioners to visit the delivery system daily to restock baits, which could limit their use in remote environmentally sensitive areas and possibly reduce their use by wary feral swine. A feral swine-specific oral delivery system with a greater bait capacity is needed for management-appropriate field applications.

## PRELIMINARY DATA ON THE HOGHOPPER™ ORAL DELIVERY SYSTEM IN THE U.S.

Concomitant to the development of HOG-GONE®, a proprietary bait matrix specifically designed to deliver toxic levels of sodium nitrite to omnivores, researchers with the Invasive Animals Cooperative Research Centre in Australia and Animal Control Technologies Australia developed the HogHopper™ as a feral swine-specific oral delivery system (Lapidge et al. 2011). The HogHopper™ is designed to exploit unique attributes of feral swine such as reach, size, strength, and feeding behavior to prevent non-target exposure during baiting campaigns. The HogHopper™ also has a large enough capacity to eliminate daily practitioner maintenance, making it suitable for baiting remote, environmentally-sensitive areas. The HogHopper™ is composed of a metal cube with interior divider, which allows feral swine to access baits on two sides through guillotine gravity-charged doors (Figure 2).

Our objectives are to determine feral swine and non-target animal removal rates of non-toxic HOG-GONE® delivered through the HogHopper™. We have performed 33 independent field trials in Texas, Florida, Alabama, and Oklahoma from December 2010 - August 2011. Additional trials will be conducted in the states mentioned plus Mississippi and Missouri. Our trials involved a prebaiting phase with whole-kernel corn and doors open, a non-toxic HOG-GONE® phase with doors open, and a non-toxic HOG-GONE® phase with doors closed or activated. Wildlife visitation and bait removal was determined through motion-sensing photography (Reconyx, Holmen, WI). Our preliminary findings (Figure 3) suggest feral swine bait removal declined from the prebaiting phase to the open with HOG-GONE® phase, indicating a preference by feral swine for whole corn over HOG-GONE® baits. For raccoons, bait removal declined from open to closed phases. However, raccoons breached the HogHopper™ during 3 trials when units were activated. In all of the trials with raccoon breaches, the duration of the prebaiting period was >3 weeks. This long prebaiting period was conducted to stimulate use by feral swine, but it allowed raccoons time to learn and discover how to operate the HogHopper™ guillotine door. This information will be used in developing the label for the product, which will include an abbreviated prebaiting phase. We observed no breaches for other species, including white-tailed deer, collared peccaries, striped skunks (*Mephitis mephitis*), opossums (*Didelphis virginiana*), and coyotes. Data from our completed study will be used in requesting an experimental use permit from

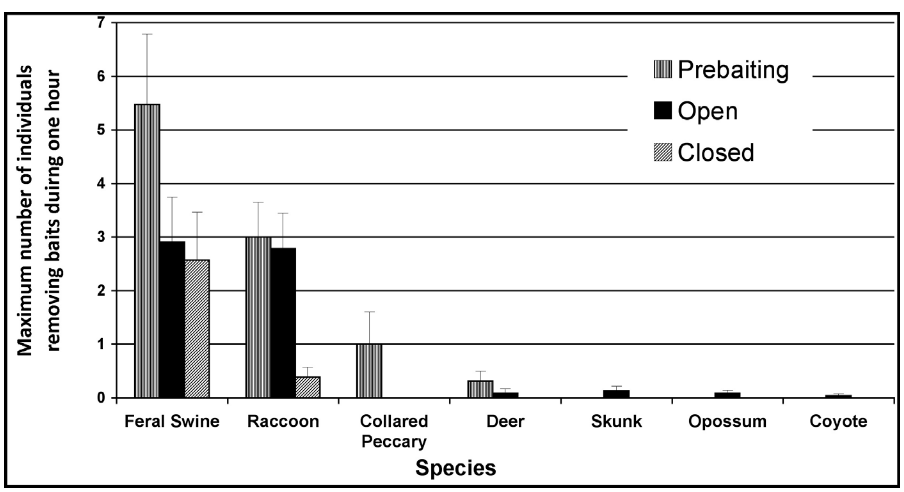


**Figure 3. Mean (SE) maximum number of individuals removing baits during one hour by period (prebaiting with corn, open with HOG-GONE® baits, and closed with HOG-GONE® baits) during HogHopper™ trials conducted in Texas (28 trials), Florida (2 trials), Alabama (2 trials), and Oklahoma (1 trial) from December 2010 - August 2011.**

the U.S. Environmental Protection Agency for field trials involving toxic HOG-GONE®.

## FUTURE FERAL SWINE ORAL DELIVERY SYSTEMS

Design features for future feral swine oral delivery systems should be driven by the desired end use. For example, it is important to identify what demographic group is being targeted (sounders or individual animals, adults or piglets), whether it is important to check delivery system daily or infrequently (i.e., whether bait capacity is important), and what biologic, chemical, or pharmaceutical is to be delivered (fertility control agent, disease vaccine, or toxicant). Another important consideration in developing and selecting a feral swine oral delivery system is its cost. Numerous factors contribute to the cost of a system, including size, composition (durable or temporary, portable or fixed, availability of materials), simplicity of assembly, and availability of local manufacturers. These expense factors should be weighed relative to the effectiveness of the system and desired application. Based on successes demonstrated in other disciplines (Azimi-Sadjadi et al. 2008), there is interest in emerging technologies, such as image and audio recognition systems, that allow or deny access of selected species to baits containing biologics at feeder systems. None of these technology-based systems have been proven effective and they are presently cost-prohibitive. While there is a real need for a feral swine-specific oral delivery system, presently there is no universally effective system suitable for all applications and field scenarios. Each system has its advantages and disadvantages that must be assessed within its management context. Further research is needed aimed at developing such tools.

## ACKNOWLEDGEMENTS

This paper was funded by U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services National Wildlife Research Center, Animal Control Technologies Australia P/L, and Invasive Animals Cooperative Research Centre. We appreciate the many property owners who granted property access to conduct trials. We thank M. Avery, F. Boyd, F. Cunningham, K. Grant, K. Fagerstone, J. Foster, B. Leland, D. Long, S. Swafford, R. Taylor, E. Tillman, J. Wishart, and the many field personnel for assistance with data collection. The USDA does not recommend endorsement, guarantee nor warrant companies or commercial products mentioned in this paper.

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