Development of a Feral Swine Toxic Bait (Hog-Gone®) and Bait Hopper (Hog-Hopper™) in Australia and the USA

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ABSTRACT At the 13th Wildlife Damage Management Conference, the primary author delivered a paper titled "Is America ready for a humane feral pig 'toxin'?" The toxin, sodium nitrite, a common meat preservative that prevents botulism, had previously been shown to be a quick-acting and low-residue toxicant for feral pigs in Australia and has since been patented. Pigs are particularly sensitive to nitrite-induced methemoglobinemia because they have low levels of methemoglobin reductase, the enzyme required to reverse the effects of nitrite toxicosis. Over the last two years, a great deal of progress has been made towards developing a nitrite bait and a suitable bait delivery vehicle for feral pigs. Field trials of Hog-Gone® in Australia are now complete and a registration dossier is currently being finalized. The dossier details the pharmacology and humaneness of nitrite toxicosis, pen and field trial efficacy, pen and field carcass residues, and the nontarget safety and environmental fate of nitrite. Nontoxic trials of smaller bite-sized Hog-Gone baits, delivered in the Hog-Hopper™, are currently occurring in multiple sites and seasons in Alabama, Florida, Mississippi, Missouri, Oklahoma, and Texas. Results thus far are encouraging, and may lead to future trials if environmental safety is demonstrated. Concurrently, an Environmental Protection Agency registration dossier is being prepared to request the experimental-use permit needed for field trials of the formulated bait. Engagement with industry and animal welfare groups also continues to be positive. Detailed within, in brief, are the achievements of the last two years and the future of the project in Australia and the USA.

KEY WORDS feral pig, humane, nitrite, omnivore, pesticide, registration, *Sus scrofa,* swine.

FERAL PIGS IN AUSTRALIA

Four to 24M feral pigs (Hone 1990) occur in Australia, with populations covering 40% of the Australian land mass. Current feral pig distribution in Australia is depicted in Fig. 1. Feral pigs cause at least $100M per annum economic impact to agricultural (McLeod 2006), which is likely an underestimate, and untold damage to the environment. They are recognized as a key threatening process to threatened species and ecological communities due to their predation, habitat degradation, competition, and disease transmission. They are a declared pest animal in most states and territories and must be controlled by law. Choquenot et al. (1996), Cowled et al. (2008a) and Lapidge et al. (2009) provide further details on feral pigs in Australia and the background to the project detailed within.

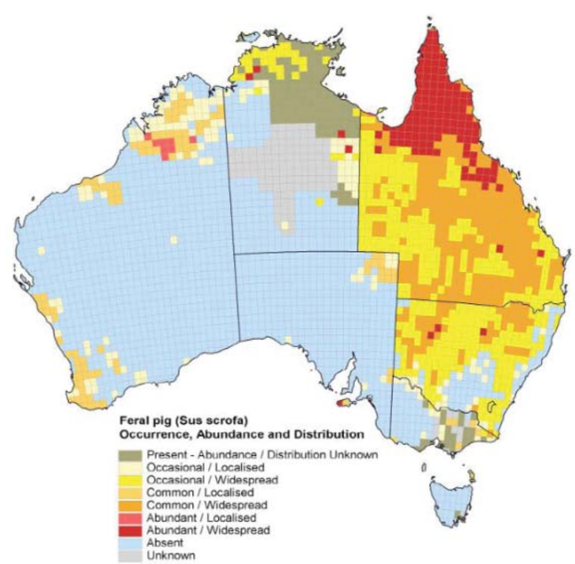

Figure 1. Feral pig distribution in Australia

FERAL SWINE IN THE USA

Feral swine have spread from 9 states 30 years ago to 44 states today (Figure 2), and unless strict confinement and eradication measures are enacted it is anticipated that they will be in every state within the next few years. The current swine population is anecdotally estimated to be 4 million individuals, which is also likely to be an underestimate. Pimentel et al. (2000) predicts that the economic impact of feral swine in the U.S. is near $1 billion annually. Unlike Australia, feral swine have a mixed legal status in U.S., including that of an invasive species, a game animal (now the second most hunted in the U.S.), and in some states, they remain unclassified. Campbell and Long (2009) provide a summary of feral swine impacts in the U.S.

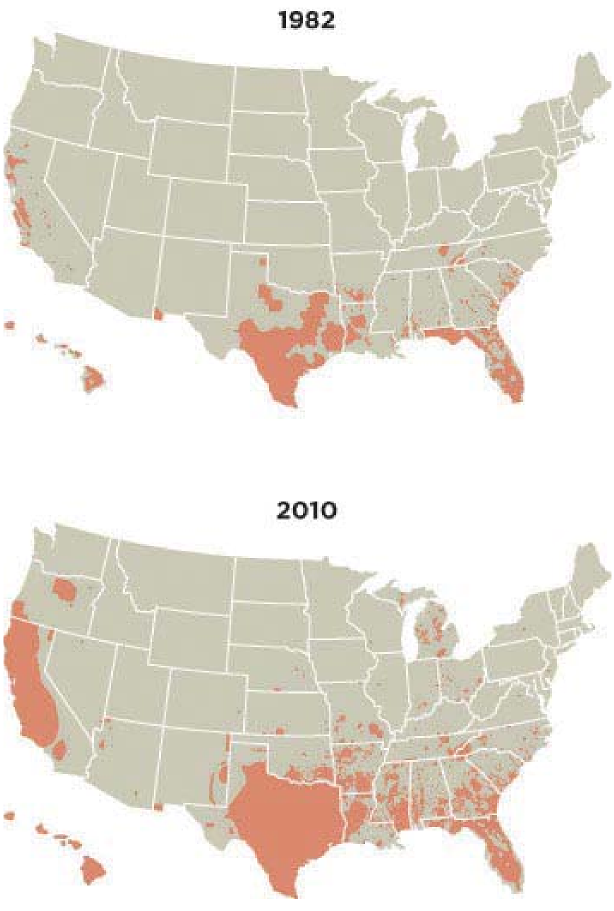

Figure 2. The spread of feral swine in the USA over the last 30 years.

CURRENT CONTROL OPTIONS

With the exception of poisoning in Australia and snaring in the U.S., both countries use the same feral pig control techniques. These include ground shooting, which generally has low efficacy; aerial shooting, which has higher efficacy but is only suited to restricted environments; trapping, which has low efficacy and is labor-intensive; and fencing, which is expensive, often ineffective, and rarely used. Hunters commonly use dogs to hunt pigs in both countries, although this technique also has low population control efficacy and raises humaneness concerns.

Increasingly, the welfare standards by which feral swine and all invasive animals are controlled are coming under public scrutiny. In particular, Australia has seen the withdrawal and banning of two feral pig toxicants (warfarin and yellow phosphorous) in recent years due to legitimate animal welfare concerns. Poisoning is often perceived as inhumane, regardless of the chemical used. The authors challenge this notion and propose that the ultimate humaneness of any of the above control techniques must be considered in light of the total control intervention presented to individual pigs, from engagement to death, not just the final blow. A humane control technique is a clean head shot to a feral swine without pursuit. In our opinion, use of sodium nitrite, which causes 20–30 minutes of mild symptoms, including ataxia, labored breathing, unconsciousness and death, is likely to be more humane than many of the control options currently available that deprive an animal of its freedom for much longer periods of time.

PROPOSED CONTROL OPTIONS

Cowled et al. (2008a) and Lapidge et al. (2009) detail the initial investigations into the potential use of sodium nitrite as a vertebrate pesticide for feral swine. Cowled et al. (2008b) details the patent that was filed on bait-delivered nitrite as a vertebrate pesticide, which has been granted in Australia and is pending elsewhere, including in the U.S. In brief, nitrite causes methemoglobinemia, which results in rapid depletion of oxygen to the brain and vital organs. Pigs are highly susceptible to this mode of action because they lack methemoglobin reductase, the naturally occurring enzyme required to reverse the toxicosis. Nitrite causes a rapid death in domestic pigs in approximately 1 hour (IMVS 2010) and in feral pigs in 1.5 hours (Cowled et al. 2008a), with symptoms (detailed above) lasting less than 30 minutes (IMVS 2010). Nitrite toxicosis through methemoglobinemia has been independently assessed as humane (IMVS 2010).

Sodium nitrite is presented in a proprietary bait matrix specifically designed for omnivores (it combines animal and vegetable material). This product has been trademarked as Hog-Gone®. Hog-Gone baits in Australia weigh 200g and can be presented without the need for a species-specific hopper due to the lack of large opportunistic omnivores in the country. In contrast, as demonstrated by Campbell et al. (2006) and Campbell and Long (2007), Hog-Gone baits in the U.S. will require a species-specific bait hopper due to the abundance of sympatric opportunistic omnivores. When presented in a hopper device (detailed below), it is better to use smaller bite-sized baits, as smaller pigs may remove baits from the device and consume them nearby, which could lead to toxic crumbs being left in the environment. As such, 70g Hog-Gone baits of the same matrix are currently being tested in the U.S., as depicted in Figure 3.

Figure 3: 70g omnivore nontoxic Hog-gone baits currently being tested in the U.S.

FIELD EFFICACY

Field efficacy trials, comprised of paired but independent treated (toxic baiting) and non-treated sites (placebo baiting) up to 100 km² each, and ideally containing 50+ individual pigs at each site, have been conducted in a diverse range of habitats and climatic conditions where feral pigs occur in Australia (Figure 4). At each site, up to 20 cluster bait stations are established, often near water points. Stations are pre-baited with fermented grain and nontoxic Hog-Gone until the feeding feral pig population plateaus, as indicated by nightly assessment of the number of individual feral pigs (or maximum number in a single photo.) Feeding at each bait station each night as recorded on Reconyx® remote cameras. The same amount of toxic Hog-Gone bait is then introduced at the treatment site, after which, station monitoring continues for at least four days. Separately and independently, remote cameras are established at nearby drinking areas and on well-used game trails to photograph pigs that are in the area that may not be feeding at the bait stations. These animals are included in the population efficacy assessments.

Field trial results are as follows, with locations indicated on Figure 4:

A. Glenrock Station, New South Wales, temperate ranges used for cattle production, April 2009. 89% population reduction.

B. Namadgi National Park, Australian Capital Territory, sub-alpine sclerophyll forest, May 2009. 63% population reduction (due to compromised baits and taste aversion).

C. Eaglebar Station, Queensland, temperate grasslands used for cattle production and sorghum cropping, March 2011. 83% population reduction.

D. Harmar Station, Queensland, temperate grassland used for cattle production, March 2011. 82% population reduction.

E. Lassie Creek Station, Queensland, tropical grassland used for cattle production, May 2011. 68% population reduction.

Figure 4: Location of Hog-gone field trials in Australia in different habitats and climatic zones.

NONTARGET CONCERNS

Primary Poisoning Risk

The overall nontarget mortalities for all field trials combined, consisted of 1 cow (A) and 4 common birds (A and C) for the removal of approximately 300 feral pigs. Therefore, collateral damage was less than 1.7%.

The susceptibility of 8 eutherian mammals to sodium nitrite has previously been published, and is summarized in Cowled et al. (2008a). As nitrite is a direct methemoglobin former, methemoglobin reductase levels can be used to predict species susceptibility to the chemical. Methemoglobin reductase levels can be ascertained directly from blood samples, circumventing the need for lethal trials. Lapidge and Eason (2010) summarizes methemoglobin reductase levels published in Australia for 28 marsupial species, 4 reptile species, and 2 bird species, from which approximate lethal doses have been calculated. In the U.S., lethal nitrite doses have been directly ascertained for raccoons and white-tailed deer. Good Laboratory Practice (GLP) avian toxicology studies have also been undertaken on bobwhite quail (*Colinus virginianus*), mallards (*Anas platyrhynchos*), and red-winged blackbirds (*Agelaius phoeniceus*) . The susceptibility of bears, collared peccary (*Pecari tajacu*), and other potential nontarget species should be predicted indirectly from blood samples.

REDUCING EXPOSURE

As discussed above, bait-delivery to feral swine in the U.S. will require the development of a pig-specific hopper. Recently in Australia, the Hog-Hopper™ has been developed and commercialized to allow peace-of-mind feral pig baiting in national parks and around

Figure 5: Feral pigs feeding from the Hog-Hopper during product development field trials.

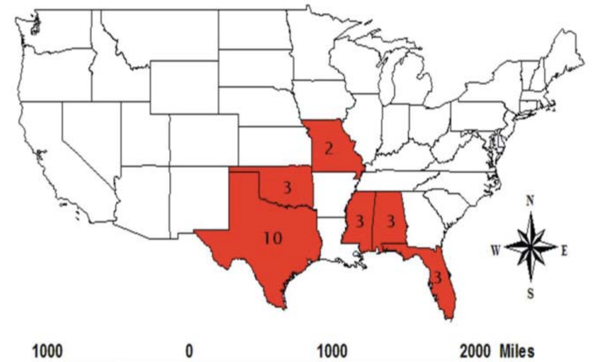

Figure 6: Current state locations of Hog-Gone- Hog-Hopper field trials and number of hoppers deployed.

livestock (Fig. 5). The same units are currently being tested in Alabama, Florida, Mississippi, Missouri, Oklahoma, and Texas as detailed in Fig. 6. Multi-season and multi-location field trials using corn and 70g nontoxic Hog-Gone baits commenced in late 2010 and continued for 12 months. Although initial results are generally encouraging, there has been a breach of the hopper by a raccoon (*Procyon lotor*), and pigs have extensively damaged some hoppers. Furthermore, pigs found the baits less attractive in some locations, and thus bait enhancements are currently being investigated.

SECONDARY POISONING RISK

Secondary poisoning risks from consuming nitrite-killed or sub-lethally poisoned feral pigs was predicted to be minimal due to:

- Nitrite plasma half-life being 29 to 62 minutes in rats, humans, sheep, dogs and horses, so sub-lethal doses are rapidly eliminated;
- Most nitrite being converted during the toxicosis; and
- The need for a pulse dose to cause fatal methemoglobinemia, which is difficult to extract quickly from digested meat.

To clarify, hunters or wildlife would not be at risk from consuming sub-lethally or lethally poisoned feral pigs, as confirmed by residue testing on pen and field-poisoned feral pigs. Thigh muscle, eye, liver, small intestine, stomach, and vomit samples were assessed, most at day 1, 3, 5, and 7 post- death. Results will be the subject of a separate journal publication, but in summary, nitrite residue levels in thigh muscle, eye, liver, and small intestine were less than that allowed in bacon (100mg/kg). Furthermore, maximum muscle residues were less than nitrite concentrations found in most vegetables. The only residue concerns are associated with undigested stomach contents and vomit, although vomiting has never been detected in field-poisoned feral pigs. In summary, only scavengers that consume stomach contents, such as canids and vultures, may be at risk and this should be directly tested in pen and field trials.

ENVIRONMENTAL RISK AND DECAY

Nitrite is toxic to aquatic organisms. As such, nitrite levels are currently being assessed in three water bodies of different sizes following a worst-case scenario contamination incident (40 baits). Once values are obtained, risks will be determined for a range of fish species based on the many published fish and aquatic organism nitrite susceptibilities.

An important and often-asked safety question is how long do Hog-Gone baits take to decompose? This is currently being assessed in three different scenarios: dark and cold conditions, exposed spring conditions, and high summer temperature conditions. Nitrite concentrations will be assessed monthly in Hog-Gone baits from each environment. Early indications are that high temperatures will quickly render baits non-toxic. The presentation of baits in hoppers in the U.S. will likely extend bait life but also ensure containment of unconsumed baits.

HOG-GONE PROGRESS TO DATE

Investigations into sodium nitrite as a feral pig toxicant commenced in Australia in 2005 (Cowled et al. 2008a) and in New Zealand in 2008. Since that time, laboratory and pen trials have confirmed the humaneness and efficacy of the active ingredient. Toxic field trials of Hog-Gone have subsequently proven it to be very effective in reducing feral pig populations, with the average population reduction being 79%. Final data packages are now being assembled into a Hog-Gone registration dossier, which was initially submitted to the Australian Pesticide and Veterinary Medicine Authority in July 2011. Product registration and launch is predicted to be in 2013. Research is also currently commencing into the development of a nitrite concentrate that can be mixed with corn or grain bait.

THE TESTING OF HOG-GONE AND HOG-HOPPER IN THE USA

The Hog-Gone and Hog-Hopper project commenced in late 2010 by USDA APHIS Wildlife Services, coordinated by the National Wildlife Research Center, with additional Texas collaborators (Texas Parks and Wildlife Services and Rick Taylor). Twenty-four Hog-Hoppers are currently being tested across 6 states in various seasons since November 2011 (Fig. 6). Hog-Gone will likely need to be modified to be more attractive to the local feral pig palate, and hoppers have required reinforcing and may yet require heavier doors. If these issues can be resolved, many of which already have, and subject to EPA approvals, toxic field trials will be undertaken in 2013. An initial U.S. Environmental Protection Agency (EPA) registration meeting was held in September 2010 and was highly encouraging regarding eventual registration. Potential USA registration submission of Hog-Gone is currently anticipated in late 2015.

ACKNOWLEDGMENTS

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