Development of a Novel Vertebrate Pesticide for the Invasive Small Indian Mongoose

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ABSTRACT: Small Indian mongooses are detrimental introduced predators in the United States, where they depredate native species, serve as vector of disease, and threaten public safety. Due to the risk of accidental introduction to mongoose-free islands, high cost and limitations to trapping, and no national (Section 3) Environmental Protection Agency (EPA)-registered toxicants for mongoose control, there is a need for an efficacious toxic bait for mongooses for use in conservation areas and at points of entry in the United States. Over the last five years, the National Wildlife Research Center (NWRC) worked to develop a toxic bait for mongooses for registration with the EPA. This paper outlines the development pathway to registration of a toxic bait for mongooses in the United States.

KEY WORDS: invasive species, registration, regulatory requirements, small Indian mongoose, toxicant, *Urva auropunctata*, vertebrate pesticide development

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INTRODUCTION

Small Indian mongooses [*Urva auropuncta* (syn. *Herpestes auropunctatus*)] are invasive to the United States and are currently established on Hawai‘i, O‘ahu, Maui, and Moloka‘i in Hawai‘i; in Puerto Rico; and in the U.S. Virgin Islands. Mongooses pose a threat to the eggs and nestlings of native ground-nesting birds and other native species (Hays and Conant 2007). Mongooses pose a health risk to humans, as they carry leptospirosis in Hawai‘i (Wong et al. 2012) and the Caribbean (Everard et al. 1976, Cranford et al. 2021), and are a rabies reservoir in the Caribbean (Seetahal et al. 2018). Trapping is the primary method for mongoose control but has limitations. While effective on a small scale, trapping is labor-intensive, not feasible over large and/or inaccessible areas, and is ineffective at preventing immigration of mongoose into the targeted conservation area. In addition to trapping, toxicants can improve ongoing mongoose control programs and enhance rapid response to new invasions. The threat of accidental or intentional introductions to currently mongoose-free islands in the Hawaiian chain (e.g., Kaua‘i and Lāna‘i) and other Pacific locations highlights the need for a comprehensive menu of control techniques, including attractive and palatable baits and effective toxicants, to quickly respond to reported sightings or incipient mongoose populations (Phillips and Lucey 2016).

BACKGROUND

Currently in Hawai‘i and on other islands in the Pacific Basin and in the Caribbean, live-traps are predominately employed to control mongooses (Smith et al. 2000, Barun et al. 2011). In Hawai‘i, a 50 ppm diphacinone wax bait block product (SLN No. HI-980005) is co-labelled for use on rodents and mongooses. However, the bait block, which was originally designed to control rodents, showed relatively poor efficacy with wild-caught mongooses in a laboratory study conducted by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center (NWRC) (Sugihara et al. 2018).

METHODS

We summarize the research and regulatory steps to develop an effective and palatable toxic bait for mongooses. Details on registration and regulatory requirements are described in Antaky et al. (*In Press*). To screen potential toxicants, NWRC evaluated the efficacy and palatability of 10 commercial rodenticide baits, fresh minced chicken formulations of technical diphacinone powder, and two alternative acute toxicants against mongooses in a laboratory (Sugihara et al. 2018). Overall, the acceptance of the 10 commercial rodenticide products was low while the acceptance of the toxicants mixed with fresh minced chicken remained high. NWRC then conducted a feasibility assessment comparing the registration potential of a new toxic bait for mongooses containing one of the four most efficacious candidate active ingredients identified by Sugihara et al. (2018) (Ruell et al. 2019). Of these four candidates, diphacinone is already a registered active ingredient in multiple rodenticides; is already registered for use in bait stations for mongooses and invasive rodents on islands; has the lowest primary risks to nontarget species as it requires multiple feedings to be fatal for most species; and has an easily accessible and known antidote (vitamin K), which when combined with the relatively slow mechanism of action, provides time to administer the antidote in the event of an accidental exposure to humans and pets. Additionally, mongooses are known to be particularly

susceptible to diphacinone, with a median lethal dose (LD_{50}) of 0.18 mg/kg body weight (Keith et al. 1990).

The next step was to pair the selected toxicant, diphacinone, with an attractive bait matrix to mongooses. Previous trials at NWRC evaluating the attractiveness of selected lures, scents, and food products helped inform the selection of potential bait matrices to test (Pitt and Sugihara 2008, Pitt et al. 2015). A new bait matrix will ideally be highly palatable for mongooses but have better field longevity than fresh meat baits. A subsequent NWRC laboratory study evaluated the palatability of non-toxic versions of four potential bait matrices that were previously developed or in development for other carnivore and omnivore pest species, to determine which of the candidate matrices had adequate palatability for mongooses to warrant future consideration as a toxic matrix (Siers et al. 2020). Based on these evaluations, the fish-based bait matrix (a preserved bait type with better longevity and shelf life) was selected for its combination of palatability, likely stability, and ease-of-use.

This fish-based bait matrix combined with diphacinone at the standard concentration used in rodent baits for field use (0.005%) was called "Fish-based Bait for Mongooses," and was further tested in a Good Laboratory Practices (GLP) two-choice laboratory efficacy trial with wild-caught mongooses: in this trial, there was 85% mortality in the treated group and 0% mortality in the control group during the five-day two-choice test and 15-day post-test monitoring periods (Sugihara et al. 2021). The Fish-based Bait for Mongooses appeared to be a palatable and efficacious bait for mongooses. The GLP lab study report is currently under review by the EPA.

In addition to the mongoose laboratory and field efficacy trials, data, and reports, EPA requires further laboratory and chemistry studies on the toxicant product for registration. These include a GLP 5-batch analysis study and GLP Certificate of Analysis Study, which confirms the uniformity and consistency in toxicant concentrations within the manufactured bait matrix and must meet GLP guidelines listed in EPA OPPTS/OCSPP 830.1800 and US-EPA 40 CFR Part 160 under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Additional studies also include GLP pH and elevated temperature stability study, and GLP 1-year bait storage stability and corrosion study. NWRC successfully started and/or completed all the required chemistry studies for the Fish-based Bait for Mongooses.

To meet the next step of requirements for EPA registration, NWRC applied for an Experimental Use Permit (EUP). The product performance (field) GLP trials under the EUP needs to meet EPA requirements, demonstrate high mongoose morality, and show low risk nontarget interaction. Additionally, NWRC is currently evaluating an effective bait station design that targets mongooses, reduces consumption by rodents (the primary bait co-consumer), and excludes other nontarget species including native birds. Various bait station designs and prototypes will be trialed in the laboratory and in the field before the EUP trials. The EUP trails will use the "Fish-based Bait for Mongooses" delivered in the selected tamper-proof bait station design.

DISCUSSION

NWRC's research continues momentum towards a Section 3 (National) registration of a toxic bait for mongooses. Approval of an EUP permit is expected at the end of 2022, with subsequent product performance trials expected for completion in 2023. The final step is to submit a Section 3 registration application to the EPA which will include the results from the GLP products performance (EUP field) study, and any other information identified by the EPA during their review of the EUP application. Due to EPA review times, we anticipate a timeline of 2 to 3 years to securing the forthcoming registration.

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