USDA APHIS Wildlife Services
National Wildlife Research Center
Hawaii Field Station

Mongoose Control Method Development FY22 Final Report:

Efficacy trial of a mongoose toxicant for use as a conservation tool in Hawai‘i

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Report to Hawaii Invasive Species Council

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FY 2022 Update

In fiscal year 2022 we experienced administrative delays in the availability of funding and the approval of our Experimental Use Permit from the Environmental Protection Agency because of new regulatory procedures. However, we were able to form a partnership with the Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife with additional funding to conduct field efficacy trials of a fish-based diphacinone bait to control mongooses at two wetland habitats, Kawainui Marsh and Pouhala Marshs on O‘ahu. A third site representing and urban port of entry site is the Kilauea Military Reservation in Hilo, Hawai‘i Island. The compliance for these trials has been completed and field work at the first site, Pouhala Marsh, O‘ahu is scheduled to commence 24 July 2023. The timeline of milestones is outlined below.

- Although the agreement 22-7415-1603-RA between NWRC and HIDLNR was executed 14 February 2022, funds did not become available in the APHIS system until late January 2023.
- We collaborated with the Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DLNR DOFAW) on the U.S. Fish and Wildlife Service’s Competitive State Wildlife Grant (C-SWG) Program “Enhancing mongoose control to benefit endangered Hawaiian waterbirds” and notification of award was received on 23 August 2022.
    - Agreement 23-7415-1676-RA between NWRC and DLNR DOFAW was fully executed on 15 December 2022 and pass through became available to NWRC on 27 April 2023.
    - Field work at the first site, Pouhala Marsh, O‘ahu will begin 24 July 2023.
- NWRC protocol QA-3524 “Field evaluation of “Fish-based Bait for Mongooses” was approved 17 April 2023 (Appendix 1).
    - Informal consultation in accordance with section 7 of the Endangered Species Act with the US Fish & Wildlife Service for the Proposed Mongoose Bait Study at Kawainui Marsh and Pouhala Marsh, O‘ahu 2023-0018696-S7-001 was approved 14 December 2022.
- The Environmental Protection Agency’s (EPA) Experimental Use Permit for “Fish-based Bait for Mongooses” was submitted in January 2022 and approved 22 March 2023 (Appendix 2).
    - The EPA’s new procedures required independent concurrence for informal consultation with the US Fish & Wildlife Service in accordance with section 7 of the Endangered Species Act for the Proposed Mongoose Bait Study at Kawainui Marsh and Pouhala Marsh, O‘ahu, 2023-0018696-S7-001 which was approved on 6 April 2023
- Veterinary Services permit for importing “Fish-based Bait for Mongooses” was renewed 24 May 2023.
- Animal Control Technologies (Australia) Pty Ltd began producing toxic bait for upcoming field trials on 17 May 2023.
- Publications
    - A conference proceedings manuscript was published in the Proceedings of the Vertebrate Pest Conference (Appendix 3) and a manuscript was accepted for publication in the journal Management of Biological Invasions (see products).

EXECUTIVE SUMMARY

With the support of Hawaii Invasive Species Council (HISC) FY2018 funding, the Hawaii Field Station and Registration Unit of the Wildlife Services National Wildlife Research Center (WS-NWRC) performed cage feeding trials evaluating the acceptance by mongoose of four nontoxic bait matrices (NWRC Study Protocol QA-2832). The results of this study concluded that all four test materials could prove suitable as potential matrices for a toxic mongoose bait, and that the final candidate would be selected based on usability, durability, compatibility with the selected toxicant, and availability from a commercial pesticide manufacturer.

HISC FY2018 funding also supported a NWRC Registration Unit/Hawaii Field Station review of the registration and use prospects for potential toxicants to be paired with a selected bait matrix was previously reported in 2020. Considering the decision factors included in this review and determining the quickest and most cost-effective path to producing a mongoose bait available to conservation practitioners, we concluded that diphacinone was the best candidate toxicant given known efficacy in mongooses, previous registration of a product containing diphacinone for mongoose control in Hawaii, and familiarity of practitioners, bait manufacturers and pesticide regulators with the chemical.

Although a NWRC-produced pork loaf product originally developed as a bait for invasive Brown Treesnakes in Guam had the highest consumption rates, it was not selected as a desirable matrix due to uncertainty about durability (e.g., tendency to spoil) and lack of a commercial manufacturer. The matrix with the second-highest consumption was a nontoxic version of FOXSHIELD® (Animal Control Technologies; ACTA, Australia). FOXSHIELD is a fish-flavored bait formulated with 1080 (sodium fluoroacetate) for introduced fox control in Australia. It is available as a preserved pressed block or sectioned sausage form factors.

HISC FY2019 funding supported the necessary work to establish a testing and registration pathway to coupling diphacinone with the nontoxic components of the FOXSHIELD matrix as a potential solution for a toxic bait for mongoose control in conservation areas urban ports of entry locations in Hawaii and other islands with invasive mongooses globally.

We were able to establish ACTA as a willing partner to produce a version of their bait containing diphacinone, both in small batches for testing purposes and potentially as the future commercial manufacturer of a fish-flavored diphacinone bait for mongoose control. We also secured the cooperation of Bell Laboratories (Madison, WI) to provide the powder concentrate version of diphacinone for ACTA to incorporate into their fish-flavored bait matrix. NWRC has recently entered into a Cooperative Research and Development Agreement (CRADA) with ACTA for further development of a toxicant product for mongooses.

As per the objectives of the HISC FY2019 funding agreement, we conducted cage efficacy trials of a fish-based bait for mongooses formulated with 0.005% diphacinone (QA-2834). This trial was conducted to Good Laboratory Practices (GLP) standards, for eventual submission to the United States Environmental Protection Agency (EPA) in support of a pesticide registration. Additional data, including field efficacy trials, will be required before EPA approves registration for use in conservation areas and ports of entry. EPA also requires that the Fish-based Bait for

Mongooses may only be applied in tamper-resistant bait stations or other enclosed PVC pipe bait stations designed for mongooses.

HISC FY2020 funds supported the evaluation of mongoose toxicant bait station designs to prevent non-target risk and reduce bait interference by rodents and other consumers, but was delayed because of an administrative error and funding for this work was not received by USDA until May 10, 2021. The purpose of this work is to continue HISC funded mongoose toxic bait development by engineering and testing a tamper-resistant bait station to protect native species and prevent bait consumption and removal and caching of bait, mainly by rats. The primary focus of this component is to evaluate a prototype bait station concept against additional designs to develop a practical and effective bait station for mongooses. Modified versions of the PVC tube inverted "T" bait station (Keith et. al. 1989), commercially available sturdy plastic rodenticide bait stations and novel prototype designs were evaluated. Bait station designs were initially tested in laboratory enclosure trials with a placebo version of the fish-based ACTA bait matrix. Bait station visitations, bait spillage and removal were monitored with motion detection game cameras and daily bait consumption quantified. Selected bait station designs with placebo baits were then field tested in habitats representative of biosecurity and conservation application scenarios. Incorporation of cameras onto bait stations will increase their value in surveillance scenarios (e.g., Kauaʻi, Lānaʻi) where confirmed evidence of mongoose detection is critical to prevent establishment on these other islands.

Because Hawaii DLNR intended to provide the funds in advance for this project, the agreement was created as a "ROWA" (prepaid) in USDA's financial management system (FMMI) rather than a "ROWE" (pay after the work is done) account. ROWAs as prepaid agreements do not have a functioning accounting code until the payment is received and applied, therefore work on this project could not begin. Because the total amount of $21,070 was not received until May 10, 2021, and the period of performance was originally set to expire on May 31, 2021, an amendment to the workplan was implemented to extend the period of performance to May 31, 2022. No expenditures were made against this agreement prior to May 31, 2021. The timeline for this work was consequently be delayed by one full year, however captive laboratory trials and field trials have been completed, and a report for the captive trials has been completed and a report for the field trials is being currently drafted. NWRC Hawaii Field Station was also awarded $31,684.51 in October of 2021 to conduct "Field Trials of Mongoose Toxicant Efficacy Under an EPA Experimental Use Permit" but these funds have not yet been received from HISC.

The remainder of the body of this report is background on the need for invasive mongoose control tools and prior research on toxic baits for mongoose control (Part I) results of laboratory trials (Part II), captive laboratory trials and field trials for the evaluation of mongoose toxicant bait station design (Part III), execution of a CRADA (Part IV), application for an Experimental Use Permit (Part V), and recent products (Part VI). HISC funds were used to support important components of these studies, and the remainder of the expenses were funded from the NWRC Hawaii Field Station and the NWRC Registration Unit. A breakdown of expenditures of HISC funding is included as Part VII.

PART I: BACKGROUND[4]

Small Indian mongooses (*Urva auropuncta* [syn. *Herpestes auropunctatus*]), introduced to Hawaii, Puerto Rico, the U.S. Virgin Islands, Japan and numerous other sites worldwide, are serious predators of native wetland, seabird and upland forest avian species (Nellis and Everard 1983; Yamada and Sugimura 2004; Hays and Conant 2007). Mongooses are well established across most of the main Hawaiian Islands (Hawaii, Oahu, Maui and Molokai) where they pose a serious threat to the eggs and nestlings of native ground-nesting birds (Hays and Conant 2007). The threat of accidental or intentional introductions to other mongoose-free islands in the Hawaiian chain (e.g. Kauaʻi, Lānaʻi) and other Pacific locations highlights the need for a comprehensive array of control techniques, including attractive and palatable baits and effective toxicants, to quickly respond to reported sightings or incipient mongoose populations (Pitt et al. 2015; Phillips and Lucey 2016; Berentsen et al. 2018). Mongooses also present a health risk to humans as hosts of leptospirosis in Hawaii (Wong et al. 2012) and the Caribbean (Everard 1976), and as a rabies reservoir on several islands in the Caribbean (Seetahal et al. 2018).

Various strategies have been used to reduce or remove mongoose populations in Hawaii and elsewhere, including trapping and toxic baits. Trapping has been useful in reducing mongoose populations and predation in and around targeted sensitive native areas (ground-nesting upland and seabird colonies). Trapping, however, is labor-intensive, expensive, and only removes mongooses from limited areas (Barun et al. 2011, Sugihara et al. 2018, Berentsen et al. 2018). Toxic baits can provide a more effective and longer-lasting approach to eradicate mongooses from a larger area.

Earlier studies by Keith et al. (1989) found diphacinone to be highly toxic to mongooses with a lethal dose (LD50) of 0.18mg/kg body weight. Successful lab and field efficacy trials with diphacinone formulated in a fresh meat bait culminated in a local registration (SLN Reg. No. HI-91004, EPA Reg. No. 12455-9). The SLN label allowed registered applicators to formulate 0.00025% (2.5ppm) of diphacinone in fresh ground beef placed in tamper-proof bait stations deployed in the field to protect ground-nesting native birds. At the registered concentration (0.00025%) the fresh bait had to be maintained in bait stations over an extended period (up to 14 days) to cause mortality by multiple days of feedings by mongooses. The logistics of applicators having to prepare fresh bait formulations regularly, limited bait longevity and other constraints resulted in discontinuance of the SLN registration, mainly due to difficulty in use (Sugihara et al. 2018).

Two commercial diphacinone rodenticide bait products were subsequently approved for mongooses. The rodenticide baits, co-labeled for rats and mongooses, were formulated at 0.005% (50ppm) active diphacinone, the active concentration of most diphacinone baits registered for rats and mice. "Eaton's® All Weather Bait Blocks Rodenticide with Fish Flavorizer™" (0.005% diphacinone, SLN Reg. No. HI-97-007, EPA Reg. No. 56-44) and "Ramik® Mini Bars Kills Rats and Mice" (0.005% diphacinone, SLN Reg. No. HI-98005, EPA Reg. No. 61282-26) are both hard, waxy, grain-based, bait blocks used in bait stations to control

[4] This section was primarily written by Robert Sugihara, with review and edits by the other co-authors of this report

rats and mice. The Eaton's bait was eventually discontinued in 2004 due to rapid deterioration in the warm and humid environment in Hawaii and concerns of viable exotic plant seeds in the bait matrix (R. Sugihara, pers. comm.). The efficacy of the Eaton's bait was variable in limited field data, suggesting that this bait was less successful in areas with low mongoose density or high alternative prey density (Smith et al. 2010).

Recent WS-NWRC cage feeding trials (QA-2196) of several commercial rodenticide baits indicated that the inefficacy of commercial rodenticide formulations to mongooses was likely due to the hard consistency of grain-based pellets and blocks which are not appropriate to the dentition and feeding modes of mongooses. The registered Ramik diphacinone bait block had a fairly low efficacy (20% mortality) over a 5-day feeding period in a laboratory no-choice efficacy trial, which was likely due to low palatability and consumption of the bait rather than low toxicity to mongooses (Sugihara et al. 2018). The Ramik product remains the only registered toxicant bait available for mongoose control in the US, and this registration is state limited to Hawaii.

As part of the QA-2196 trials, technical diphacinone along with other candidate developing toxicants were formulated in fresh raw chicken, a more attractive bait matrix than the hard rodenticide bait blocks and offered to mongooses in similar 5-day feeding trials. At a concentration of 0.005% (50ppm), the normal dosage of commercial diphacinone-based rodenticide baits, technical diphacinone formulated in raw minced-chicken was found to be highly palatable to mongooses with 100% daily consumption of the fresh bait offered. The overall mortality rate was 70% for mongooses after a single day of feeding and 100% for mongooses over a 3-day feeding period. In cooperation with Japanese researchers attempting to control mongooses on Okinawa and Amami-Oshima, Japan, the 50ppm diphacinone minced chicken bait was found to be equally efficacious for mongooses in lab cage and field enclosure trials conducted in Okinawa (R Sugihara, 2016 and 2018 Japan trip reports). Subsequent experimental field trials with the diphacinone-minced chicken bait were conducted on Amami-Oshima in isolated locations along steep terrain where trapping was not feasible. Preliminary results show that the diphacinone bait was successful in eliminating the remnant mongoose population from the baited areas (T Jogahara, University of Okinawa, pers. comm.). This demonstrates the potential for optimizing the susceptibility of diphacinone to mongoose in another more palatable bait matrix with a reduced bait exposure period (Sugihara et al. 2018).

Development of an effective mongoose diphacinone bait will require a softer, palatable, more durable bait matrix that is longer lasting in the field than fresh raw meat. A recently completed lab study (QA-2832) evaluated the palatability of four candidate non-toxic bait matrices for mongooses to determine which had adequate palatability (are consumed in sufficient amounts) to warrant future consideration as a diphacinone bait matrix. The selected candidate bait matrix was the non-toxic version of a commercial predator bait in Australia called FOXSHIELD®, which is a preserved, semi-soft, fish-based cylinder bait encased in a sausage-type skin. FOXSHIELD is produced by Animal Control Technologies (Australia) Pty Ltd (ACTA) Pty Ltd in Somerton, Victoria, Australia (EPA Establishment No.: 091731-AUS-001) for invasive fox control. The

non-toxic FOXSHIELD preserved bait matrix was easy to handle and readily consumed by mongooses in the cage feeding trials (QA-2879).

Additionally, a toxicant registration evaluation was recently conducted for mongooses in Hawaii by WS-NWRC Registration Unit (Ruell et al. 2018). Of the four toxicants evaluated (based on QA-2196 lab trials), a diphacinone bait for mongooses would likely be the least expensive and quickest candidate to be reviewed and approved for mongoose control by the regulatory agencies, largely due to the abundance of registered diphacinone products and the supporting registration data already available for diphacinone.

The Environmental Protection Agency (EPA) requires laboratory efficacy data for vertebrate pesticide products in accordance with EPA OPPTS 810.1000 guidelines to support the issuance of a future Experimental Use Permit (EUP) for a larger field efficacy study and a subsequent full registration application. Building on the promising results from these previous studies, this proposed two-choice laboratory efficacy study of a bait consisting of the fish-based FOXSHIELD bait matrix containing 0.005% diphacinone continues the momentum toward the eventual goal of field deployment of an effective toxic bait for mongoose control in agriculture, biosecurity, and conservation applications.

Background References

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Part II. RESULTS OF LABORATORY TRIALS

QA-3298 Pilot study: Laboratory evaluation of the palatability of two experimental fish-based diphacinone (0.005%) baits for mongooses.

The objective of this laboratory study was an initial evaluation of the palatability of two different proprietary formulations of fish-based 0.005% (50ppm) diphacinone test baits. This laboratory cage trial evaluated the efficacy and palatability of two experimental formulations of a fish-based commercial predator bait manufactured by Animal Control Technologies (Australia) Pty Ltd (ACTA) Pty Ltd in Somerton, Victoria, Australia (EPA Establishment No.: 091731-AUS-001) based on their FOXSHIELD predator bait matrix with 0.005% (a.i) diphacinone powder. This study was a prelude to the planned GLP study (QA-2834) evaluating the efficacy of a bait consisting of the fish-based bait matrix containing 0.005% diphacinone which advances the ultimate goal of registering an effective toxic bait to be used to control mongoose in the field for agriculture, biosecurity, and conservation applications.

There was 100% mortality (6/6 mongooses) in the ACTA test bait with one formulation and 83% mortality (5/6 mongooses) in the ACTA test bait with a group treated with another formulation during the combined 5-day test period and 10-day post-test period. Both test formulations were more effective than the registered Ramik diphacinone bait block with an efficacy of 20% mortality in QA-2196. The ACTA test bait with the first formulation accounted for 77% of the total food consumed (test bait 1 + challenge diet) by mongoose while the ACTA test bait with the second formulation accounted for 69% of the total food consumed (test bait 2 + challenge diet) by mongoose in the treated groups during the 5-day two-choice test period. A final report for this laboratory trial has been drafted, circulated, and edited by primary co-authors. The first formulation was selected for subsequent expanded GLP lab efficacy trials.

QA-2834 Two-choice laboratory efficacy test in mongooses - fish-based bait for mongooses (0.005% diphacinone)

The objective of this laboratory study was to evaluate the two-choice efficacy of a fish-based 0.005% (50ppm) diphacinone test bait for mongooses conducted under GLP conditions to support an EPA experimental use permit for subsequent field trials. The first formulation from the pilot study QA-3298 was used as the toxic bait to be tested. This protocol outline, which received EPA concurrence, was primarily drafted by Robert Sugihara and Emily Ruell with input from the other co-authors on this report.

This study was divided into two separate laboratory trial of equal sample sizes of each sex to accommodate the total number (40) of treatment subjects (20) and control animals (20) required for EPA efficacy trials. In the first trial, the ACTA FOXSHIELD bait with 50ppm diphacinone caused mortality in 9 of 10 mongooses in the treatment group. In the second trial 8 of 10 in the treatment group succumbed to the ACTA diphacinone bait. Consequently, including both rounds, mortality was 17 of 20 (85%) of test subjects. All 20 mongooses given the non-toxic control bait survived. This laboratory study concluded on April 25, 2021. In the first trial, the amount of ACTA diphacinone bait consumed by the single surviving individual was low. All 20 mongooses

sampled (<1g) or consumed the toxic bait. Two survivors consumed <1g, and the other survivor consumed >1g, but regurgitated most of the toxic bait.

Part III: Evaluation of Mongoose Toxicant Bait Station Design (QA-3388 & QA-3439)

Substantial progress was made in the last year towards the development and registration of a mongoose toxicant. During fiscal year 2022, candidate mongoose toxicant bait station designs were evaluated in two studies: 1) QA-3388 examined a suite of four bait station prototype designs in captive arenas to evaluate bait station visitations, bait consumption by mongooses and to minimize bait spillage; and 2) QA-3439 examined the two best performing bait stations that were identified in QA-3388 to evaluate bait consumption by free-ranging mongooses and potential non-target interactions in the field. Other accomplishments include the execution of a Cooperative Research and Development Agreement, submission of an application package for an Experimental Use Permit to the US Environmental Protection Agency, and a manuscript summarizing the research and development of the mongoose toxicant, which has been accepted for publication.

QA-3388 "Evaluation of mongoose (*Herpestes auropunctatus*) toxicant bait stations designs in captivity to optimize use by mongooses and reduce non-target risks" found high consumption of non-toxic Fish-based Bait for Mongooses among all four bait station prototypes which were evaluated (Figure 1), including: a raised PVC tube design (A), an inverted "T" bait station design with two entry points (B), an "L" PVC tube design with a single single-entry point (C), and a raised Protecta® commercial rodenticide bait station (D). The average daily consumption did not differ significantly between prototypes, ranging from 20.65g to 31.58g. Every mongoose study subject was easily able to access each of the bait stations and consume non-toxic placebo bait every day of the study. Although average spillage differed between groups, prototype B and C had significantly less spillage than the other two designs (P=0.004).

QA-3439 "Field evaluation of prototype toxic bait station designs to evaluate use and bait take by free-ranging mongooses (*Herpestes auropunctatus*) and potential non-target interactions" evaluated a prototype bait station (C) against a modified commercially available sturdy plastic rodenticide bait station (D) based on results from QA-3388. The two bait station designs were tested in the field with non-toxic placebo baits and monitored with motion detection game cameras at two sites representative of a port of entry and a conservation area scenario. Five bait stations of each bait station design were tested at each site for 4 to 7 days. Mongooses were recorded interacting with all deployed bait stations (Figure 2, showing prototype C). Non-target species recorded in camera images at bait stations included domestic or feral goats (*Capra hircus*), *Rattus* spp, and feral pigs (*Sus scrofa*) in the background. There was no evidence that goats or pigs were able to access bait inside of the stations or spilled bait outside of the stations. A final report for QA-3439 is being drafted.

Part IV: Execution of a CRADA

A CRADA (Cooperative research and Development Agreement) was executed on January 26, 2022 between Animal Control Technologies (Australia) and NWRC. The specific research and

activities conducted under this CRADA will advance the development and registration of a fish-based toxicant bait containing Diphacinone for small Indian mongooses.

Figure 1. Mongoose bait station prototypes evaluated in captivity during QA-3388: a raised PVC tube design (A), an inverted “T” bait station design with two entry points (B), an “L” PVC tube design with a single single-entry point (C), and a raised Protecta® commercial rodenticide bait station (D).

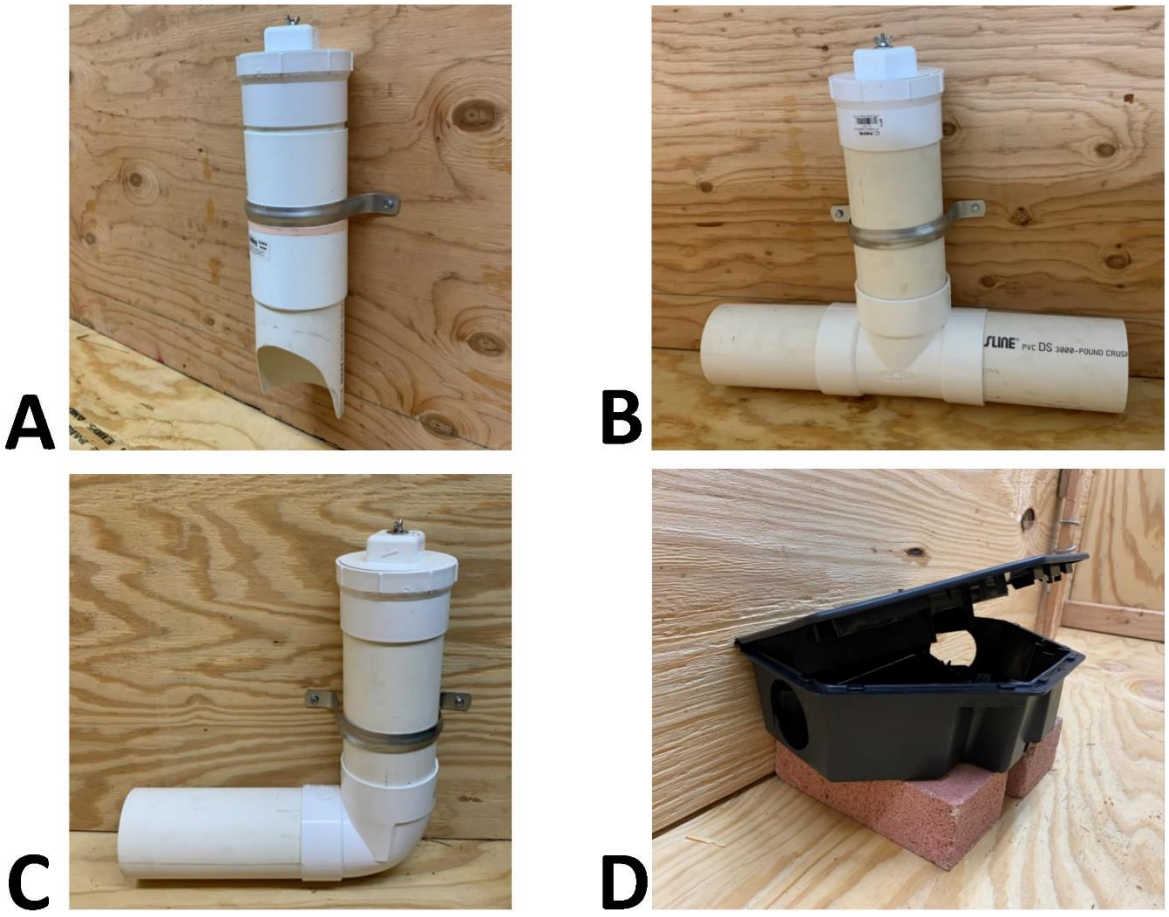

Figure 2. An example of the type C mongoose bait station evaluated in the field with non-toxic placebo bait during QA-3439. Type D Protecta® bait stations were also evaluated in the field.

Part V: Application for an Experimental Use Permit

An application package for an Experimental Use Permit (EUP) was submitted to the US Environmental Protection Agency (EPA) in January 2022 to conduct field efficacy trials of a mongoose toxicant product. The application was based on EUP Field Study Protocol "Product performance: field evaluation of Fish-based Bait for Mongooses (0.005% diphacinone)" and results from QA-2834 "Two-choice laboratory efficacy test in mongooses – fish-based bait for mongooses (0.005% diphacinone)," which was conducted under Good Laboratory Practices standards and subjected to a QA data audit and review by EPA. The EUP application was received by the EPA on February 4, 2022 and was assigned a PRIA (Pesticide Registration Improvement Act) decision date of August 3, 2022. Supporting studies that have been initiated include a 1-year storage stability study on the bait. A waiver was requested for 6-pack toxicology data based on other registrations of Diphacinone products. An application was submitted on April 15, 2022, for a USDA Veterinary Services permit to import the meat-based bait from Australia in support of the upcoming field trials. Analytical chemistry assays will be conducted at the NWRC laboratory in Fort Collins, Colorado to characterize the concentration of Diphacinone in the Fish-based Bait for Mongooses used in field trials. Other studies analyzing the color, density, physical state, and odor study were contracted to and completed by Product

Safety Labs in December 2021. The costs of these supporting studies and permit applications were covered by the NWRC Registration Unit.

A scientific journal manuscript, which summarized all the research and development of the mongoose toxicant bait supported by HISC and the timeline for national registration was submitted to *Human–Wildlife Interactions* and accepted for publication on March 15, 2022. It is currently in press at the journal. A synopsis of this work was published in the *Proceedings of the Vertebrate Pest Conference*. Another manuscript about the development and evaluation of prototype toxicant-delivery bait stations for the control of the small Indian mongoose was submitted to the journal *Management of Biological Invasions* and is currently in press at the journal. In addition, two presentations of the same content were given at the University of Hawai‘i at Mānoa, Natural Resources & Environmental Management Research Seminar Series, and the Vertebrate Pest Conference in Reno Nevada, and the Hawai‘i Conservation Conference in Honolulu.

Part VI: Products:

QA-2834 Final Report. Two-choice laboratory efficacy test in mongooses – fish-based bait for mongooses (0.005% diphacinone).

QA-3388 Final Report. Evaluation of mongoose (*Herpestes auropunctatus*) toxicant bait stations designs in captivity to optimize use by mongooses and reduce non-target risks.

QA-3439 Final Report. Field evaluation of prototype toxic bait station designs to evaluate use and bait take by mongooses (*Herpestes auropunctatus*) and potential non-target interactions (Appendix 4).

QA-3524 Study Protocol. Field evaluation of “Fish-based Bait for Mongooses” (Appendix 1).

Antaky, C. C., S. C. Hess, E. W. Ruell, I. L. Leinbach, S. R. Siers., and R. T. Sugihara. *In press*. The Path to U.S. National Registration of a Toxicant Product for the Control of the Small Indian Mongoose. Human–Wildlife Interactions.

Antaky, C. C., S. C. Hess, I. L. Leinbach, R. T. Sugihara, E. W. Ruell, S. R. Siers. 2022. Development of a Novel Vertebrate Pesticide for the Invasive Small Indian Mongoose. Paper No. 1. *in* D. M. Woods, editor. Proceedings of the 30th Vertebrate Pest Conference. Vertebrate Pest Council, University of California Davis, USA (Appendix 3).

Antaky, C. C., R. T. Sugihara, I. L. Leinbach, S. R Siers., E. W. Ruell, S. C. Hess. Development and evaluation of prototype toxicant-delivery bait stations for the control of the Small Indian mongoose (*Herpestes auropunctatus*). Management of Biological Invasions

Presentations:

Antaky, C. C., S. C. Hess, E. W. Ruell, I. L. Leinbach, S. R. Siers., and R. T. Sugihara. The path to U.S. national registration of a toxicant product for the control of the small Indian mongoose.

- University of Hawai‘i at Mānoa, Natural Resources & Environmental Management Research Seminar Series, February 9th, 2022
- 2022 Vertebrate Pest Conference, Reno Nevada, March, 10th, 2022
- 2022 Hawai‘i Conservation Conference, Honolulu, July 18th–22nd, 2022

Part VII. Budget

FY 2020

Category	**Amount**
Salary	$12,307.85
Benefits	$2,251.79
Supplies	$2,168.14
Total Direct Expense	$16,727.78
Overhead	$1,672.76
TOTAL	**$18,400.54**

FY 2021

Category	**Amount**
Salary & Benefits	$13,740.00
Equipment	$4,415.00
Supplies	$1,000.00
Total Direct Expense	$19,155.00
Overhead	$1,915.50
TOTAL	**$21,070.50**

Additional expenses for salaries, materials, vehicles, facilities, shipping, etc., including future completion of the study, were paid by the NWRC Hawaii Field Station and by the NWRC Registration Unit.