USDA
United States Department of Agriculture

NWRC Hawaii Field Station Development and Testing of Tools for Invasive Mongoose Control



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Hawaii Invasive Species Council
Brown Bag Seminar
9 September 2019

Background

History of Introductions
- Biocontrol- sugar planters (rat control)
- Hawaii, Maui, Oahu, Molokai
- Kauai (unsuccessful)
- Lanai (not introduced)

Distribution
- Hawaii, Oahu, Maui, Molokai
- Urban areas, homes, farms, agriculture
- Natural areas (forests, wetlands)
- Degraded habitats- waste areas, industrial
- Sea level to 3000m
- 10-90ha males>females

Natural History
- Generalist predator (adaptable)
- Year-round reproduction
- Omnivorous diet
- Inverts, fruits, eggs, rodents
- Scavenger- anthropogenic food, carrion
- Limited climbing, cross streams, irrigation ditches
- No natural predators

Impacts
- Predation
  - Upland and wetland ground nesting birds and eggs
  - Sea turtle eggs and hatchlings
  - Native invertebrates, including tree snails
  - Agriculture: eggs, chickens, ducks
- Disease
  - Leptospirosis
  - Rabies (Puerto Rico)
- Sanitation
  - Food processing facilities
  - Public parks, beaches (trash bins)

Historical NWRC Mongoose Research

- **Home range** size (Sugihara, HIFS)
- Food **baits** as **lures** to **bait stations** (Pitt, HIFS)
- **Diphacinone** for controlling predation of Hawaiian birds (Keith, HIFS)
- Individual based model to manage **rabies** n PR (Gilbert, Rabies)
- Home range, **density**, and rabies exposure in PR (Berentsen, Rabies)
- IDT oral rabies **vaccination** bait consumption (Berentsen, Rabies)
- Mongoose as **bio-indicator** of trace element pollution (Sugihara, HIFS)
- Review of **ecology** and **management** in North America (Berentsen, Rabies)
- Effects of mongoose **odor** on rat behavior (Tobin, HIFS)
- Population density and disease exposure in PR (VerCauteren, Rabies)
- Oral staining and **biomarkers** (Berentsen, Rabies [HIFS])
- Rabies surveillance in the US Virgin Islands (Berentsen, Rabies)
- Serologic response to ONRAB oral vaccination (Berentsen, Rabies)
- Population ecology on St. Kitts (Berentsen, Rabies [HIFS])
- **Scavenging** of mongoose carcasses (Berentsen, Rabies)
- Abundance and density in Caribbean (Berentsen, Rabies)
- Rabies surveillance in Puerto Rico (Berentsen, Rabies)
- Kauai invasive mongoose **origins** (Piaggio, **Genetics** [HIFS])

Traditional Control Tools

Cage traps
- High labor demands
- Subsequent euthanasia required
- Nontargets (captured live)

Toxicants
- Ramik Mini Bars (diphacinone)
- Low acceptance
- Secondary exposure?
- Sole option

Survey Existing Toxicants

European Journal of Wildlife Research
https://doi.org/10.1007/s10344-017-1163-9

ORIGINAL ARTICLE

Evaluation of the palatability and toxicity of candidate baits and toxicants for mongooses (*Herpestes auropunctatus*)

Robert T. Sugihara[1] · William C. Pitt[2] · Are R. Berentsen[3] · Cynthia G. Payne[1]

Table 1 Commercial and experimental toxicants and baits offered to mongooses

Product	Bait type	Active ingredient	A.I. conc. (%)
Commercial rodenticide baits			
Ramik® Green	Pellets	Diphacinone	0.005
Ramik® Green	Mini bars	Diphacinone	0.005
Rozol®	Pellets	Chlorophacinone	0.005
Brodifacoum 25 W	Pellets	Brodifacoum	0.0025
Resolv®	Soft bait packs	Bromadiolone	0.005
Boot Hill®	Pellets place packs	Bromadiolone	0.005
Fast Draw®	Soft bait packs	Difethialone	0.0025
Tomcat® Mouse and Rat Killer	Bait blocks	Bromethalin	0.01
Terad$_3$®	Bait blocks	Cholecalciferol	0.075
Terad$_3$®	Pellets	Cholecalciferol	0.075
Diphacinone technical material			
Diphacinone, dry, technical grade	Minced chicken	Diphacinone	0.005
Additional candidate toxicants			
PAPP NZ, encapsulated dry, 53% technical grade	Minced chicken	Encapsulated dry 53% technical Para-aminopropiophenone	0.075, 0.10, 0.15
PAPP JPN, formula 1: encapsulated dry, 71.6% technical grade	Minced chicken	Encapsulated dry 71.6% technical Para-aminopropiophenone	0.15
PAPP JPN, formula 2: encapsulated dry, 68.3% technical grade	Minced chicken	Encapsulated dry 68.3% technical Para-aminopropiophenone	0.15
Sodium nitrite, encapsulated dry	Minced chicken	Sodium nitrite	5.0
Sodium nitrite, encapsulated peanut butter slurry	Minced chicken	Sodium nitrite	5.0

USFWS-funded

Screening of commercial rodenticides and new AI (SN, PAPP)

Ramik MB diphacinone 20% efficacy

Tomcat bromethalin 95%

Technical diphacinone in minced chicken 100%

SN in minced chicken 10-30% (salty)

Consumption of hard rodent products low (except bromethalin)

Registration Potential-Cost

INVASIVESNET Management of Biological Invasions (2019) Volume 10 Article in press

CORRECTED PROOF

Research Article

An evaluation of the registration and use prospects for four candidate toxicants for controlling invasive mongooses (*Herpestes javanicus auropunctatus*)

Emily W. Ruell[1,*], Chris N. Niebuhr[2,3], Robert T. Sugihara[2] and Shane R. Siers[2]

Table 1. Total estimated registration data costs and EPA decision times (review periods) for end-use products (EPs; toxic baits) containing bromethalin, diphacinone, para-aminopropiophenone (PAPP), or sodium nitrite (SN) for use in bait station or burrow baiting applications only. Total registration data cost estimates include the data required for both the experimental use permit (EUP) and subsequent Section 3 registration applications. Best case scenarios assume USEPA will waive some data requirements as discussed under "Bait station and burrow baiting applications." Worst case scenarios assume USEPA will not waive these data requirements.

Active ingredient	Registered or Unregistered EP	Total registration data cost scenarios[a]		Decision time[b] (months)	
		Best case	Worst case	EUP	Section 3
Bromethalin	Registered	$125,000	$200,000	6	4–10
	Unregistered	$220,000	$300,000	6	10–12
Diphacinone	Registered	$125,000	$200,000	6	4–10
	Unregistered	$220,000	$300,000	6	10–12
PAPP	Unregistered	$810,000	$5,800,000	16	21
SN	Unregistered	$220,000	$300,000	16	21

[a]Registration data cost estimates were summed from study quotes obtained from contract laboratories in 2018, and do not include initial research and development or pilot study costs on the EP.
[b]USEPA's statutorily-determined decision times for different types of registration applications are specified under the Pesticide Registration Improvement Extension Act of 2018. Review periods begin once all the necessary data have been collected and the registration application is submitted to USEPA.

Table 2. Total estimated registration data costs and EPA decision times (review periods) for end-use products (EPs; toxic baits) containing bromethalin, diphacinone, para-aminopropiophenone (PAPP), or sodium nitrite (SN) for use aboveground spot baiting or hand-broadcast applications in addition to bait station and burrow baiting applications. Total registration data cost estimates include the data required for both the experimental use permit (EUP) and subsequent Section 3 registration applications. Total estimated data costs include those listed Table 1. Best case scenarios assume USEPA will waive some data requirements as discussed under "Aboveground spot baiting and hand broadcast applications". Worst case scenarios assume USEPA will not waive these data requirements.

Active ingredient	Registered or Unregistered EP	Total registration data cost scenarios[a]		Decision time[b] (months)	
		Best case	Worst case	EUP	Section 3
Bromethalin	Registered	$172,000	$430,000	6	15
	Unregistered	$267,000	$530,000	6	15
Diphacinone	Registered	$125,000	$200,000	6	9–15
	Unregistered	$220,000	$300,000	6	10–15
PAPP	Unregistered	$1,040,000	$6,750,000	16	21
SN	Unregistered	$275,000	$740,000	16	21

[a]Registration data cost estimates were summed from study quotes obtained from contract laboratories in 2018, and do not include initial research and development or pilot study costs on the EP.
[b]USEPA's statutorily-determined decision times for different types of registration applications are specified under the Pesticide Registration Improvement Extension Act of 2018. Review periods begin once all the necessary data have been collected and the registration application is submitted to USEPA.

HISC-funded

Diphacinone (anticoagulant)
Bromethalin (neurotoxin)
Para-aminopropiophenone (metHg)
Sodium nitrite (metHg)

Registration and commercial lab testing costs, EPA decision times

Use patterns (stations vs. broadcast)

Costs (lowest to hightest):

- Diphacinone
- Bromethalin
- SN
- PAPP

Registration Potential-Humaneness

Table 3. Humaneness metrics evaluated for each active ingredient from data compiled from the literature for a range of carnivorous and omnivorous mammalian species.

	Active ingredient			
	Bromethalin	Diphacinone	Para-aminopropiophenone (PAPP)	Sodium nitrite (SN)
Humaneness metric				
Mode of action	Neurotoxin	Anticoagulation	Methemoglobinemia	Methemoglobinemia
Level of awareness after onset of symptoms	Not reported, assumed conscious until death	Conscious until death	Loss of responsiveness occurs with increase in symptoms Loss of consciousness occurs prior to death	Loss of responsiveness occurs with increase in symptoms Loss of consciousness occurs prior to death
Clinical signs of distress or observable symptoms prior to death	Salivation Hyperactivity Hyperesthesia Myoclonia Vocalization Lethargy Hind-leg weakness Tremors Lateral recumbence Convulsions Seizures Paralysis Semicoma	Internal hemorrhage External hemorrhage Anorexia Dyspnoea Hypersensitivity Tremors Emesis Abnormal movement Lateral recumbence	Lethargy/weakness Salivation Nausea Emesis Hyperventilation Dyspnoea Cyanosis Vocalization Lateral recumbence Paddling/writhing Seizures	Lethargy/weakness Salivation Nausea Emesis Breathlessness Dyspnoea Pale skin Cyanosis Tremors Incoordination Lateral recumbence Paddling/writhing Seizures
Severity of symptoms	Severe to extreme	Severe to extreme	Mild to extreme	Mild to extreme
Duration of symptoms (period from first symptoms to death)	< 1–3 days	1–2 days to weeks	Minutes to hours	Minutes to hours
Time to death	< 1–4 days	3–21 days	< 1 hour–< 1 day	< 1 hour–< 2 days
Species represented[a]	Domestic cat Domestic dog House mouse Mongoose Norway rat	Ferret House mouse Mongoose Norway rat	Coyote Domestic cat Domestic dog Ferret Mongoose Red fox Stoat Wild dog	Common brushtail possum Feral swine Mongoose Raccoon

Table 4. Relative rank (1–4) of the four active ingredients for each humaneness metric and their overall humaneness rank (the sum total).

	Relative rank[a]			
Humaneness metric	Bromethalin	Diphacinone	Para-aminopropiophenone (PAPP)	Sodium nitrite (SN)
Level of awareness after onset of symptoms	3.5	3.5	1.5	1.5
Clinical signs of distress or observable symptoms	3.5	3.5	1.5	1.5
Severity of symptoms	3.5	3.5	1.5	1.5
Duration of symptoms (period from first symptoms to death)	3	4	1.5	1.5
Time to death	3	4	1.5	1.5
Overall humaneness rank (sum total)	**16.5**	**18.5**	**7.5**	**7.5**

Not EPA requirement

Social license

Mode of action
Awareness
Distress
Severity
Duration
Time to death

Least to most:

- Diphacinone (anticoagulant)
- Bromethalin (neurotoxin)
- SN = PAPP (metHg)

Also: antidotes, convenience of use

Improved Bait Matrices

Ramik MB and other commercial rodenticides too hard for mongoose carnivorous dentition.

HISC-funded cage trials to assess acceptance of alternatives

Candidates:

- Foxecute (meat flavor, ACTA, PAPP)
- Foxshield (fish flavor, ACTA, PAPP)
- HOGGONE (peanut paste, ACTA, SN)
- BTS bait (pork loaf with artificial mouse scent, NWRC)
- Talpirid (gummy worm, Bell, bromethalin, not tested)

Improved Bait Matrices

6 mongooses per trial
2-choice (dry dog kibble)
70g per choice
5-day exposure
4-hour exposure window

Daily consumption (g):

- Kibble 2-3
- HOGGONE 13-15
- Foxecute 14-20
- Foxshield 20-23
- Pork loaf 25-30

All likely adequate…options!

Other characteristics

- Compatibility w/toxicant
- Field & storage longevity
- Availability / manufacture
- Convenience of use

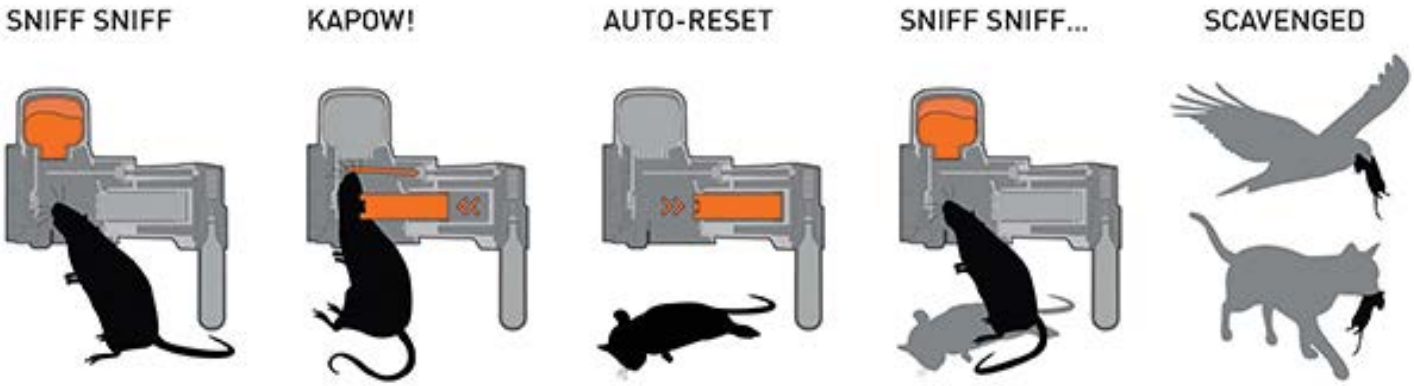
Next Steps

- Cage trials with toxic formulations (including bromethalin Talpirid)
- Matrix/AI selection, range-finding
- Field longevity trials
- Field bait uptake trials (mongoose and nontargets; partially HISC-funded FY19)
- Mongoose bait station development (partially HISC-funded FY20)
- Final cage efficacy trial to GLP standards for EPA submission (partially HISC-funded FY19)
- Field efficacy trial for EPA data submission (EUP)
- EPA lab studies, data submission and application for full product registration

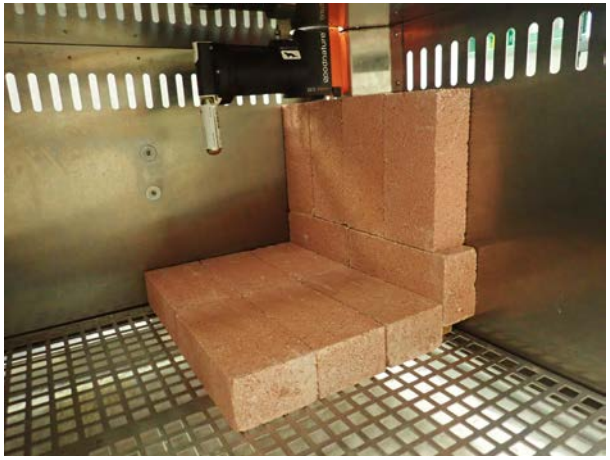
Goodnature A18

- Modification of A24 concept
- “Automatic trap”
- CO_2-fired self-resetting captive bolt
- A18 = 18 firings per cartridge
- Sold as squirrel and mink trap in EU
- In testing
- Successful field trials with USFWS

goodnature®



A18 Humaneness Trials



USFWS-PIFWO funded

NZ humaneness standard (no US standard)

Table 1: Requirements for acceptable killing effectiveness of by a 'Class A kill trap' from the New Zealand National Animal Welfare Advisory Committee (NAWAC) Guidelines.

Number of animals	Maximum allowable number of animals retaining palpebral reflex after	
	30 seconds	3 minutes
10	0	0
15	2	0
20	3	1

Mongooses conditioned to seeking food in test arena.

Continuous auditory observation (observer hidden)

Immediate monitoring of palpebral reflex upon firing

Euthanasia if reflex >30 min

A18 Humaneness Trials

Table 2: Table 2. Time to loss of palpebral reflex, respiration, and heartbeat in adult mongooses after engaging Goodnature A18 automatic mongoose kill traps. *New Zealand National Animal Welfare Advisory Committee (NAWAC) criteria was not met, euthanized via CO_2. †Palpebral reflex was not able to be checked beyond 2 min 30 sec due to animal movement and safety of the observer.

Trial #	USDA Animal ID	Date Euthanized	Sex	Final Weight (g)	Palpebral Reflex	Respiration	Heartbeat	Strike Location
1	M07	3 Jul 18	F	340	<25 sec	1 min	4 min 57 sec	lateral (left)
2	M08	6 Jul 18	M	677	<25 sec	1 min 45 sec	4 min 17 sec	lateral (left)
3	M09	6 Jul 18	F	305	<25 sec	58 sec	4 min 23 sec	lateral (right)
4	M10	11 Jul 18	M	520	<25 sec	1 min 12 sec	5 min 35 sec	dorsal
5	M11	11 Jul 18	M	605	28 sec	1 min 6 sec	2 min 40 sec	lateral (left)
6	M13	17 Jul 18	F	470	<25 sec	4 min 21 sec	1 min 57 sec	lateral (left)
7*	M15	17 Jul 18	F	358	>3 min*	>3 min	>3 min	lateral (right)
8	M16	19 Jul 18	M	590	<20 sec	1 min 12 sec	4 min 30 sec	lateral (left)
9	M18	3 Aug 18	F	403	<25 sec	1 min 32 sec	1 min 52 sec	lateral (left)
10	M19	3 Aug 18	M	477	<25 sec	1 min 8 sec	5 min 24 sec	lateral (right)
11	M20	3 Aug 18	M	611	<30 sec	2 min 29 sec	7 min 41 sec	dorsal
12	M21	10 Aug 18	F	339	<20 sec	1 min 34 sec	4 min 20 sec	lateral (right)
13	M22	15 Aug 18	M	590	<25 sec	48 sec	5 min 3 sec	lateral (left)
14	M23	9 Aug 18	F	402	<20 sec	1 min 22 sec	7 min 10 sec	lateral (right)
15	M24	17 Aug 18	F	325	<20 sec	1 min 22 sec	4 min 4 sec	lateral (right)
16	M25	21 Aug 18	M	486	<20 sec	1 min 14 sec	6 min 36 sec	lateral (right)
17	M26	29 Aug 18	F	428	<20 sec	1 min	4 min 44 sec	lateral (right)
18	M27	28 Aug 18	M	574	<30 sec	57 sec	5 min 4 sec	lateral (right)
19*	M28	2 Sep 18	M	565	>2 min 30 sec†	>3 min	>3min	lateral (left)

Number of animals	Maximum allowable number of animals retaining palpebral reflex after	
	30 seconds	3 minutes
10	0	0
15	2	0
20	3	1

A18 Humaneness Trials

Did not achieve NZ standard in NWRC trials

GN conducted follow-up field trials in Kona during May 2019

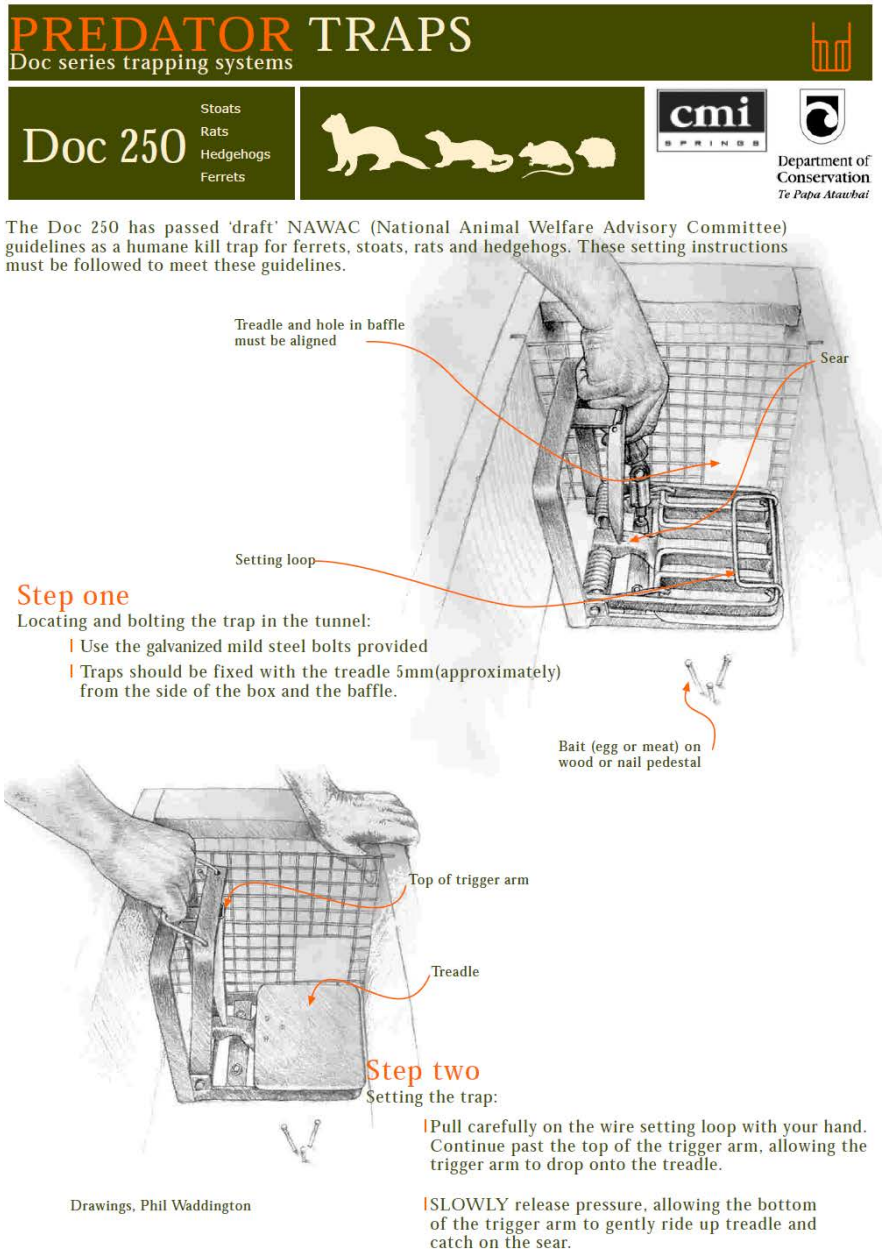
Modulated position, trigger sensitivity, piston power

Inconclusive

"*Based on this testing it is our belief that to achieve an acceptable humane standard we would need to undertake modifications to the trap and conduct more testing. At this stage we are not sure when this will happen*."

– Craig Bond

New Traps-DOC 250 Predator Traps



In use by: OANRP, TMA, NARS (Pu'u Maka'ala), James Campbell Refuge, Pacific Rim, Maui Forest Bird Project, others…more interested.

NWRC not previously involved in testing

Submitted FY20 funding request to HISC for A18/cage trap cost-effectiveness comparison

HISC recommended partnering with DOFAW on A18/DOC 250 cost-effectiveness comparison

DOFAW (Aaron Works and Lindsey Nietmann) lead

- Oahu: Control, A18, DOC 250, Mix
- Hawaii: Control, A18, DOC250

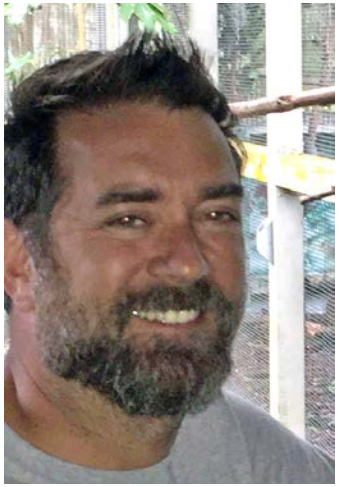
USDA United States Department of Agriculture

NWRC “Team Mongoose”

Robert Sugihara
NWRC Hilo

Israel Leinbach
NWRC Hilo

Dean Sedgwick
NWRC Hilo



Shane Siers
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NWRC Hilo/Landcare NZ

Are Berentsen
NWRC Rabies Project

QUESTIONS?

New Toxicants

New Toxicants

New Toxicants

New Toxicants

New Toxicants