DoD Environmental Planning and Conservation Webinar Series

DoD Legacy Project 18-844: Managing Invasive Ants as Threats to Endangered Insect Species on DoD Lands in Hawai‘i

August 25, 2022

Please mute your phones

Audio Dial-In: 800-300-3070

Participant Code: 642-508-534

www.denix.osd.mil/nr/

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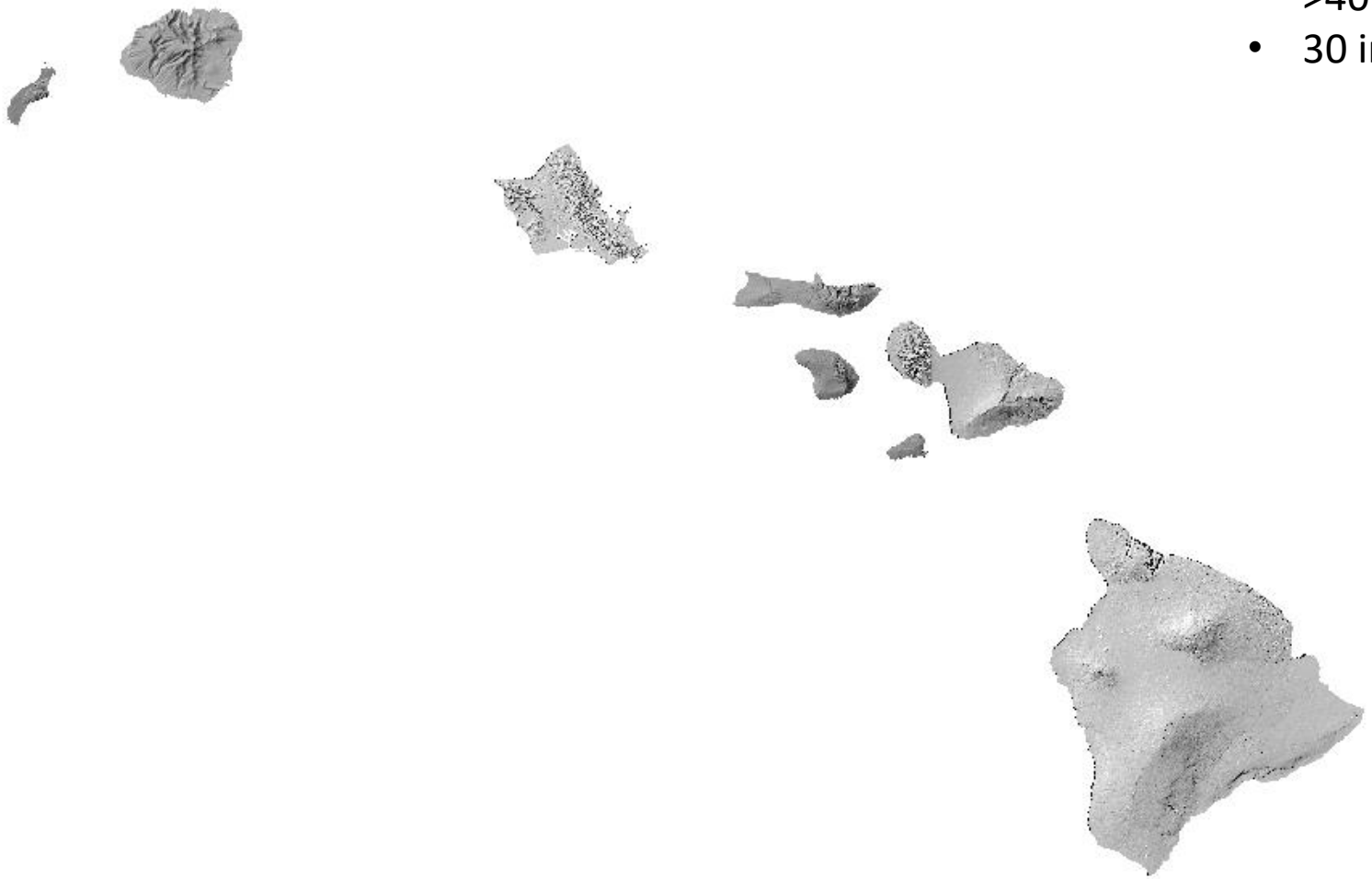
Hawai‘i: extinction capital of the world

T&E species:

- >400 plants
- >40 vertebrates
- >40 snails
- 30 insects and relatives



Hawaiian T&E Insects

14 pictured-winged flies

Photo: Karl Magnacca

7 yellow-faced bees

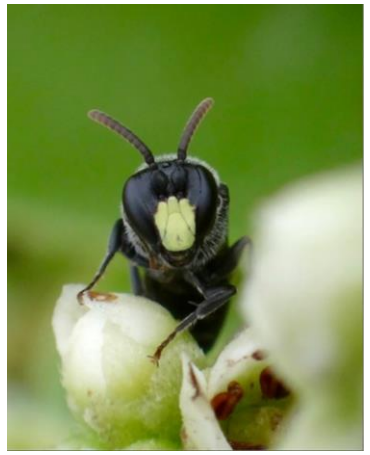


Photo: Sheldon Plentovich

6 damselflies

Photo: Will Haines

Sphinx moth

Cave wolf spider

Cave amphipod

Pacific Missile Range Facility (Navy)

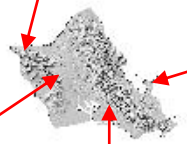
Drosophila musaphilia

Dillingham Military Reservation (Army)

Hylaeus anthracinus?

Marine Corps Base Hawaii

Hylaeus anthracinus



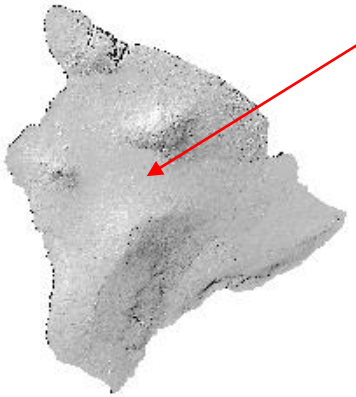
Schofield Barracks Army Base

Drosophila montgomeryi
Drosophila substenoptera
Drosophila obatai
Hylaeus kuakea

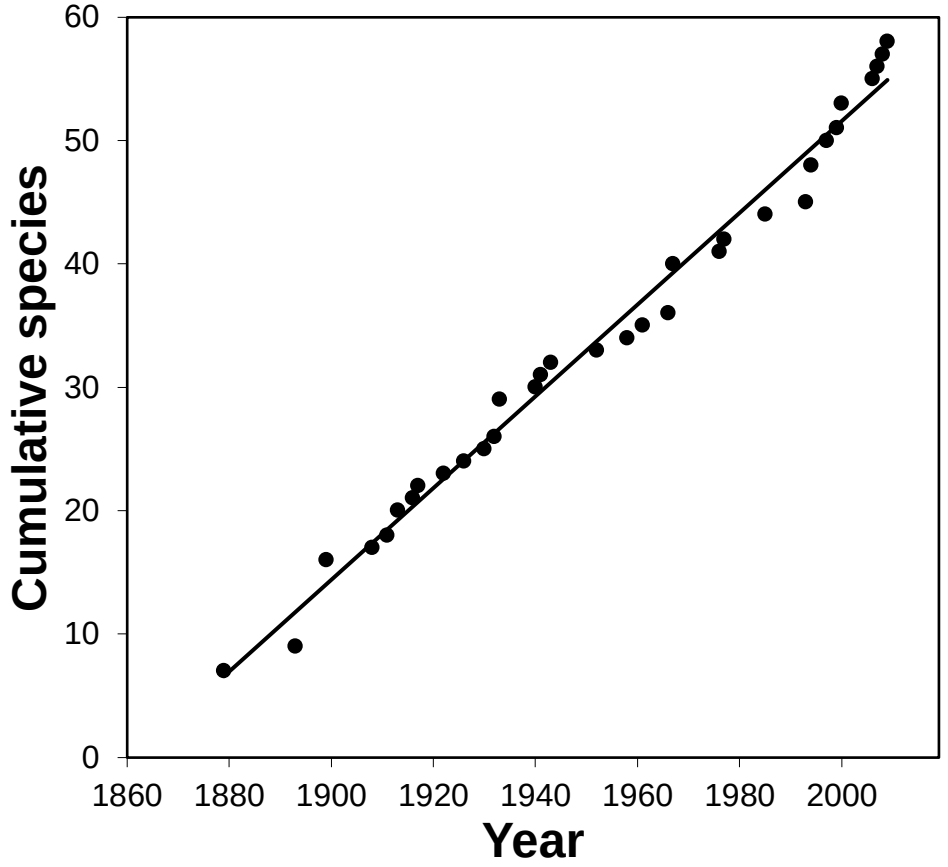
Tripler Army Medical Center

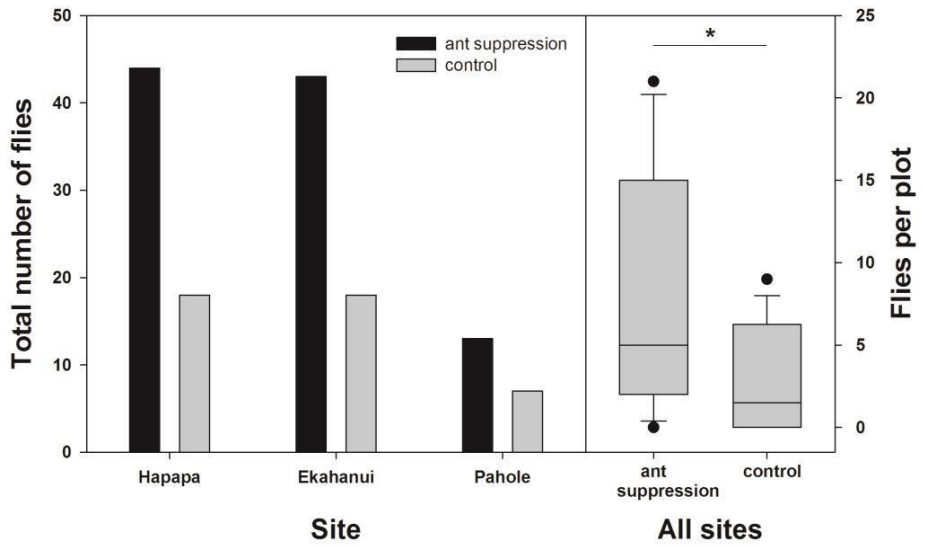
Megalagrion xanthomelas

Pohakuloa Training Area (Army)



Invasive ants have had devastating effects on native Hawaiian insects





Fly emergence was 58% lower in control plots.

(or ~2.4 times higher in ant suppressed plots)

Photo: Karl Magnacca

Krushelnycky et al. 2017. Biological Conservation 215: 254-259.

- 38% of bee nests protected from ants produced at least one adult
- 14% of unprotected nests produced at least one adult

Plentovich et al. 2021. NeoBiota 64: 137-154.

How best to manage invasive ants?

- Eradication is ideal, but not often possible.
- Methods for safe and effective suppression of widespread ant species are needed.
- Best methods for ant suppression vary among species, so distribution mapping can be critical.
- Some newer methods not yet labeled, and require additional research.

I. Mapping ant distributions on DoD installations

Pacific Missile Range Facility (Navy)

Drosophila musaphilia

Dillingham Military Reservation (Army)

Hylaeus anthracinus?

Marine Corps Base Hawaii

Hylaeus anthracinus

Schofield Barracks Army Base

Drosophila montgomeryi
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Tripler Army Medical Center

Megalagrion xanthomelas

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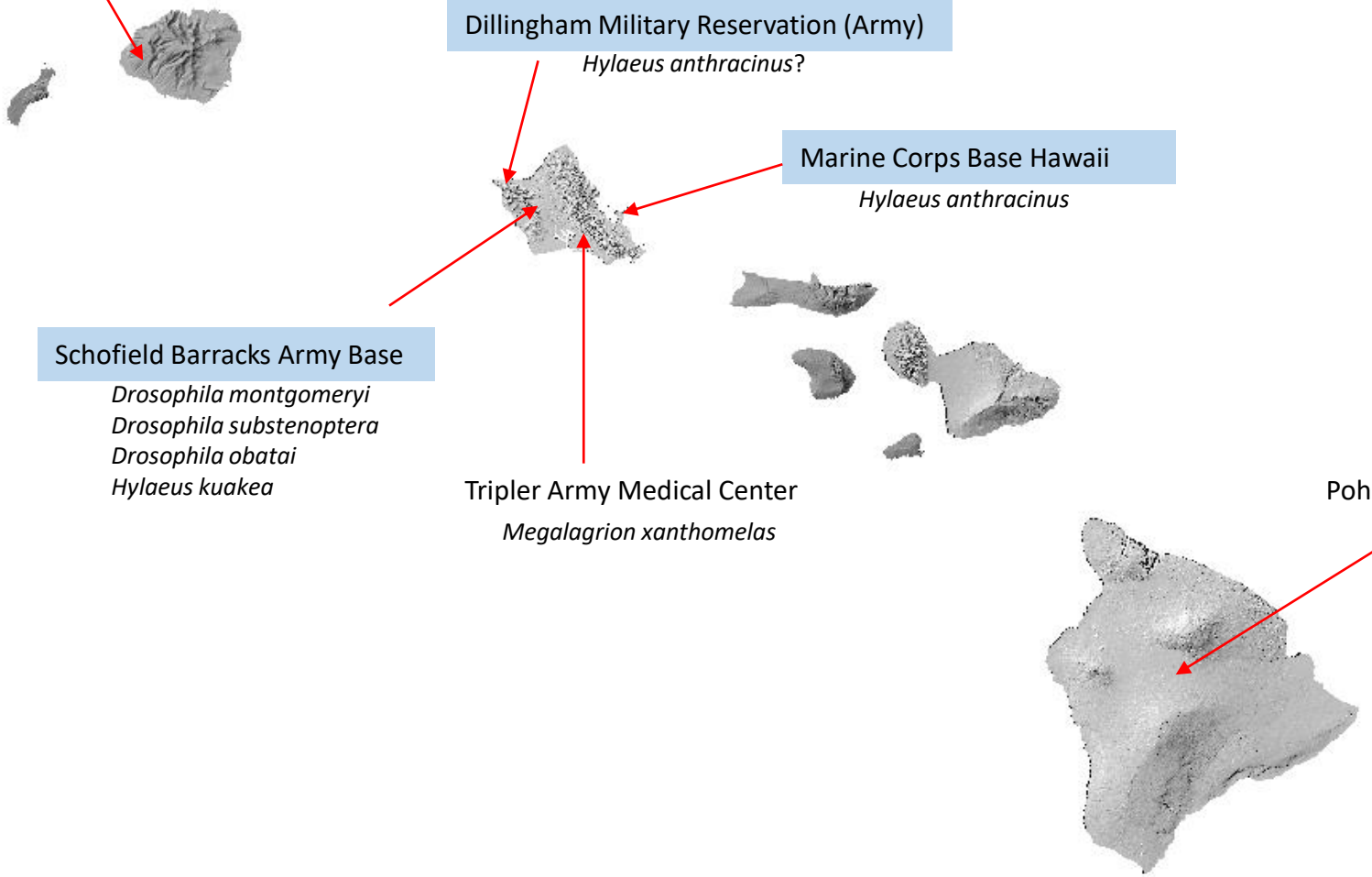


II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Pacific Missile Range Facility (Navy)

Drosophila musaphilia

Dillingham Military Reservation (Army)

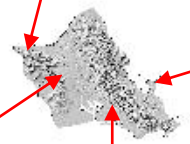
Hylaeus anthracinus?

Pheidole megacephala

Marine Corps Base Hawaii

Hylaeus anthracinus

Pheidole megacephala



Schofield Barracks Army Base

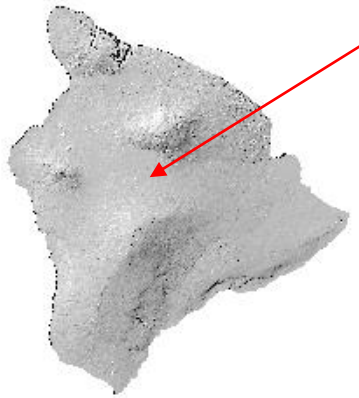
Drosophila montgomeryi
Drosophila substenoptera
Drosophila obatai
Hylaeus kuakea

Solenopsis papuana

Tripler Army Medical Center

Megalagrion xanthomelas

Pohakuloa Training Area (Army)



III. Efficacy and non-target risk for controlling ants attracted to sugarwater-based baits

Pacific Missile Range Facility (Navy)

Drosophila musaphilia

Linepithema humile

Dillingham Military Reservation (Army)

Hylaeus anthracinus?

Ochetellus glaber
Anoplolepis gracilipes

Marine Corps Base Hawaii

Hylaeus anthracinus

Ochetellus glaber
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Drosophila montgomeryi
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Pohakuloa Training Area (Army)

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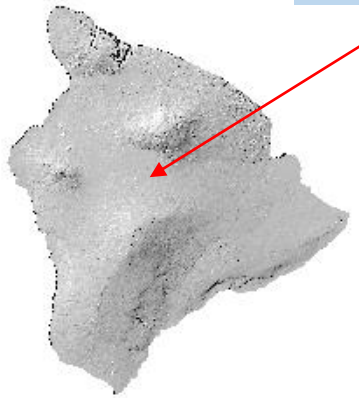


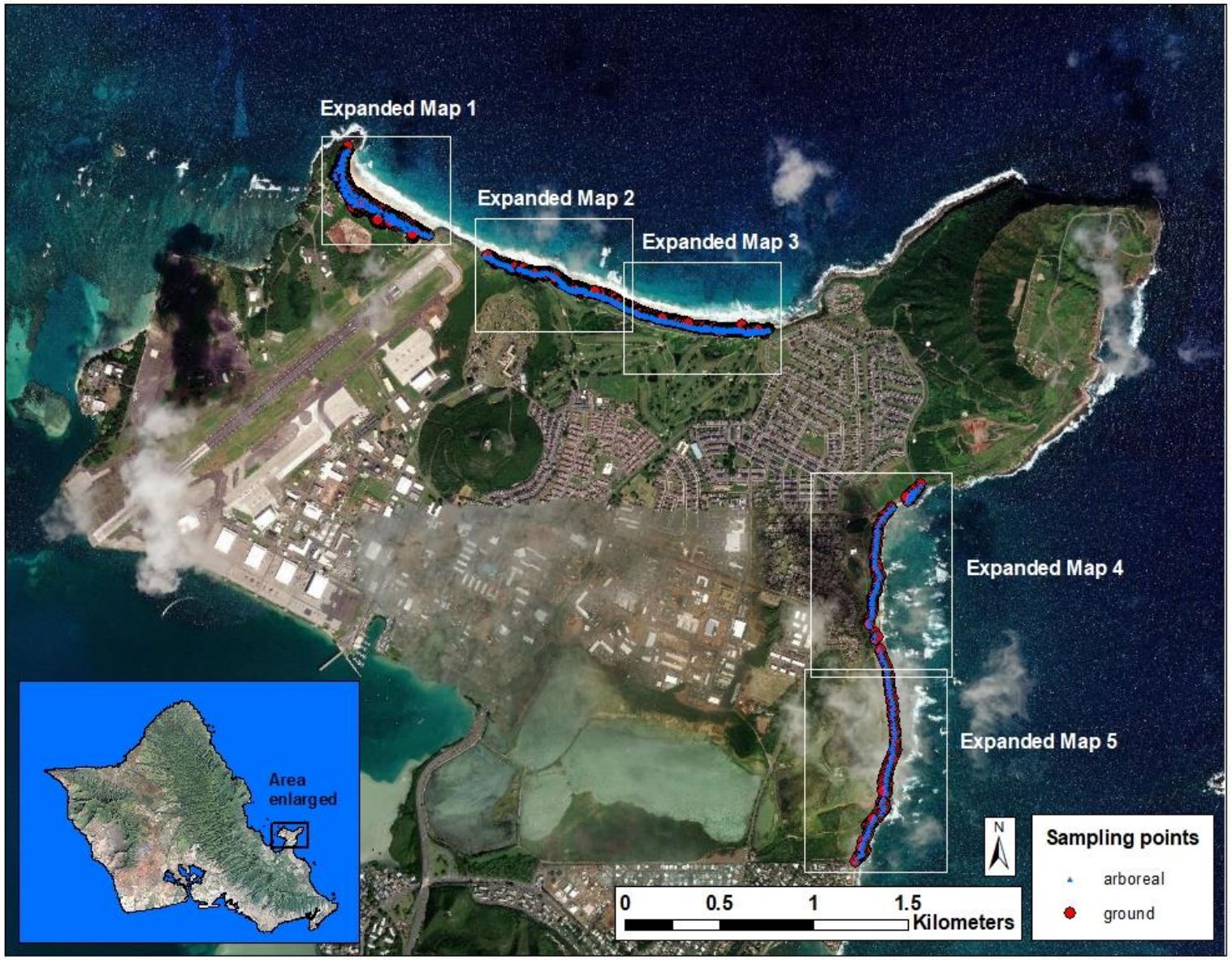
I. Mapping ant distributions on DoD installations

- For all surveys, used non-toxic baits (lures) to attract ants to cards placed on the ground or sponges tied to shrubs and trees.

- Baits for all surveys consisted of a fine slurry of Spam (42%), corn syrup (42%) and water (16%)

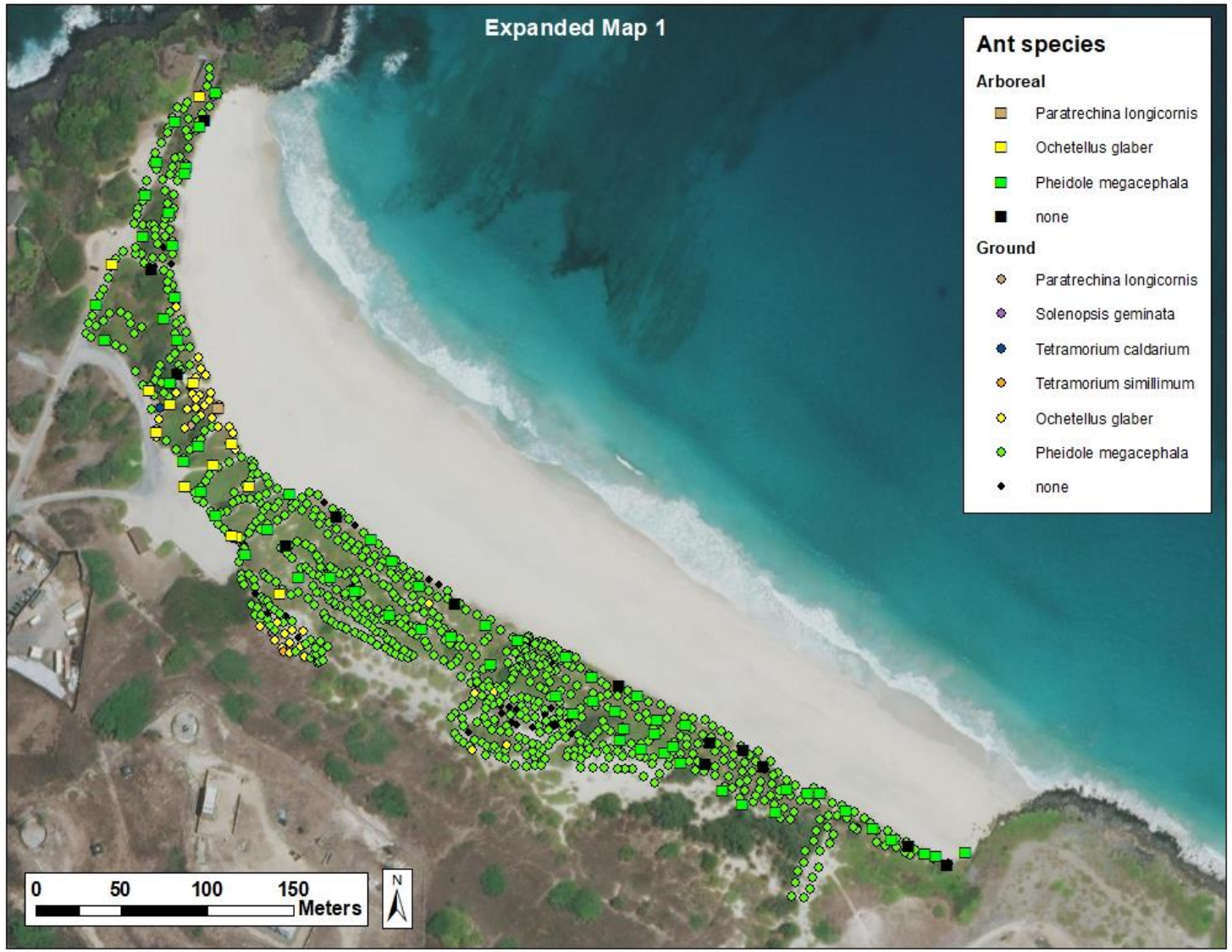
I. Mapping ant distributions on DoD installations

Marine Corps Base Hawaii



I. Mapping ant distributions on DoD installations

Marine Corps Base Hawaii



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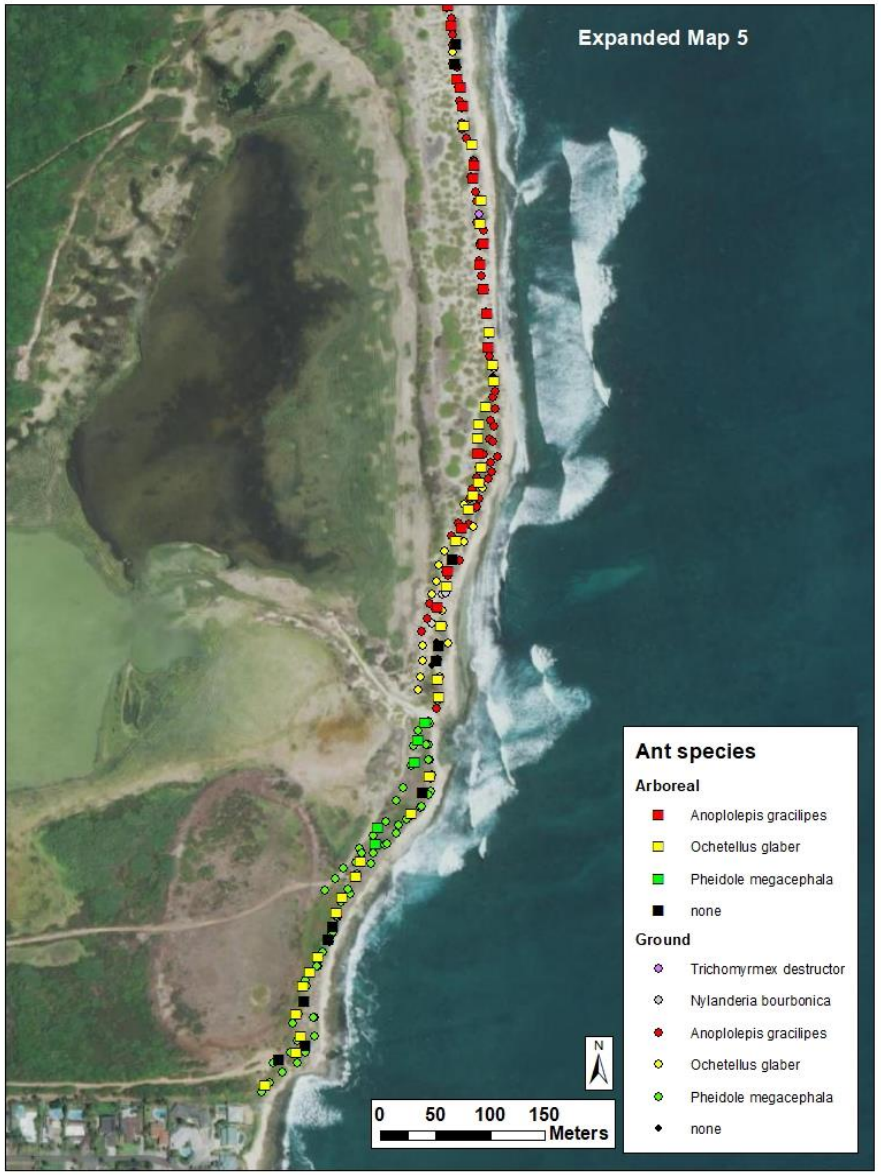
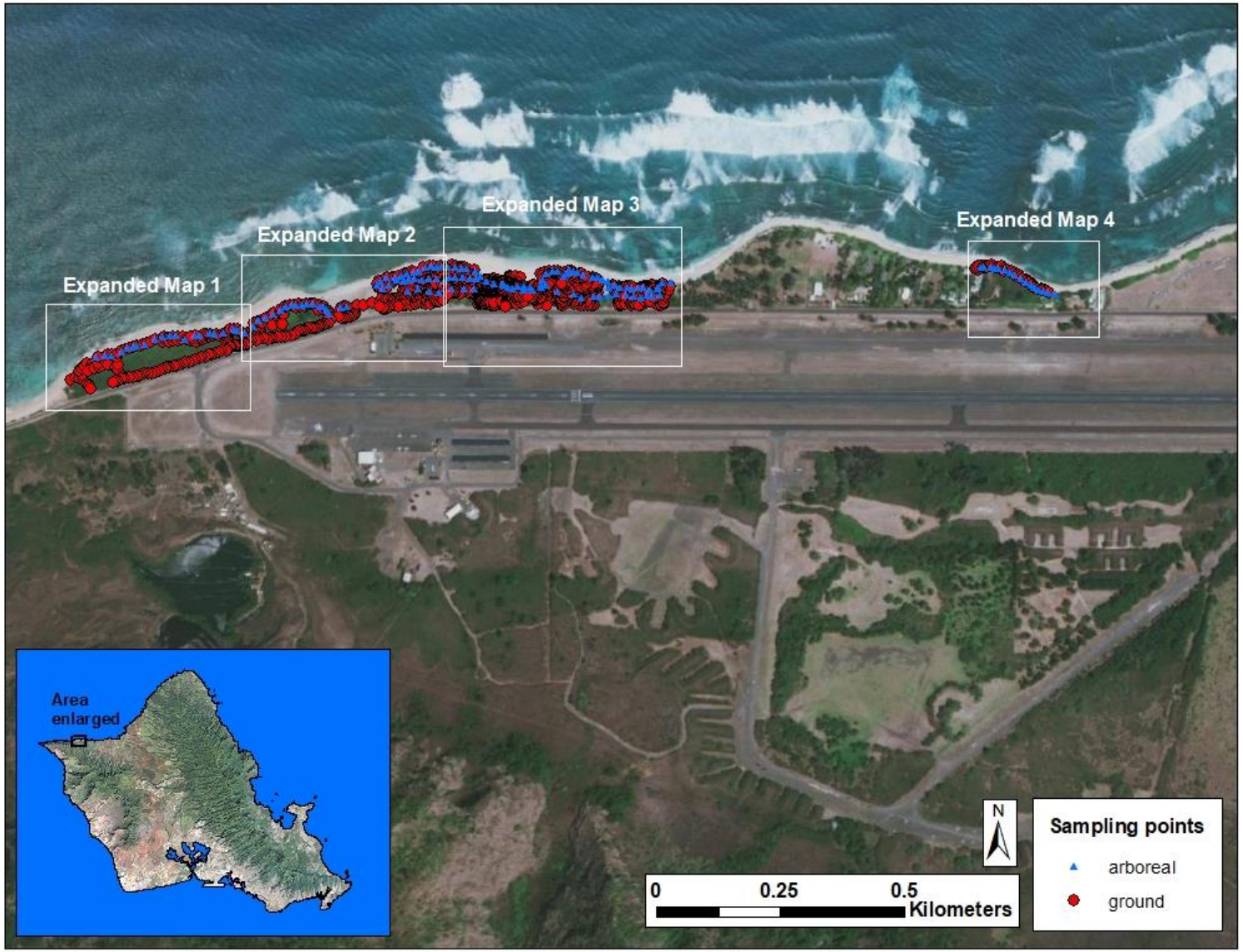
Marine Corps Base Hawaii



- 13 ant species
- Both ground and arboreal environments dominated by *Pheidole megacephala*
- *Ochetellus glaber* also common and abundant on coastal shrubs
- *Anoplolepis gracilipes* only occurs on eastern shore

I. Mapping ant distributions on DoD installations

Dillingham Military Reservation



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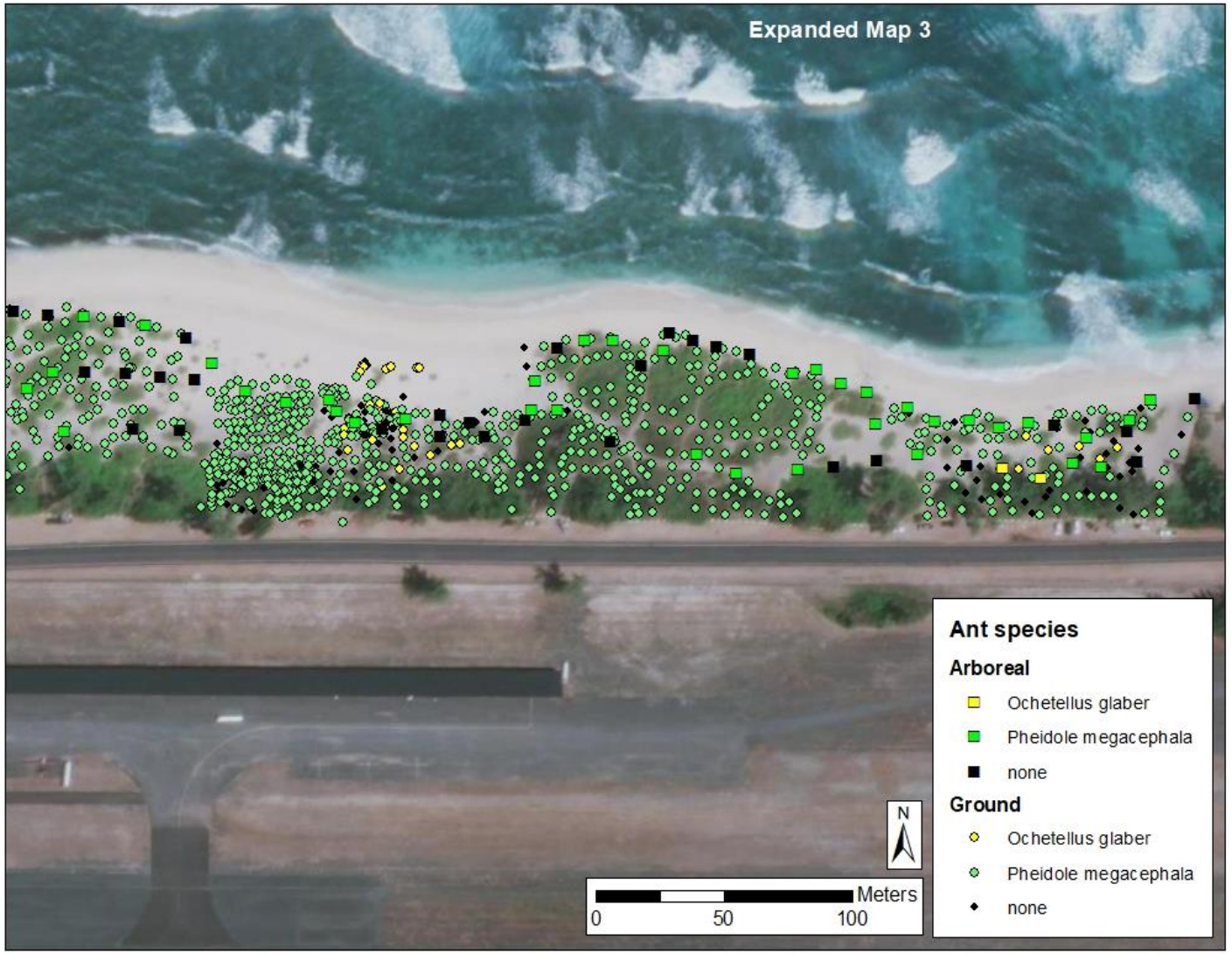
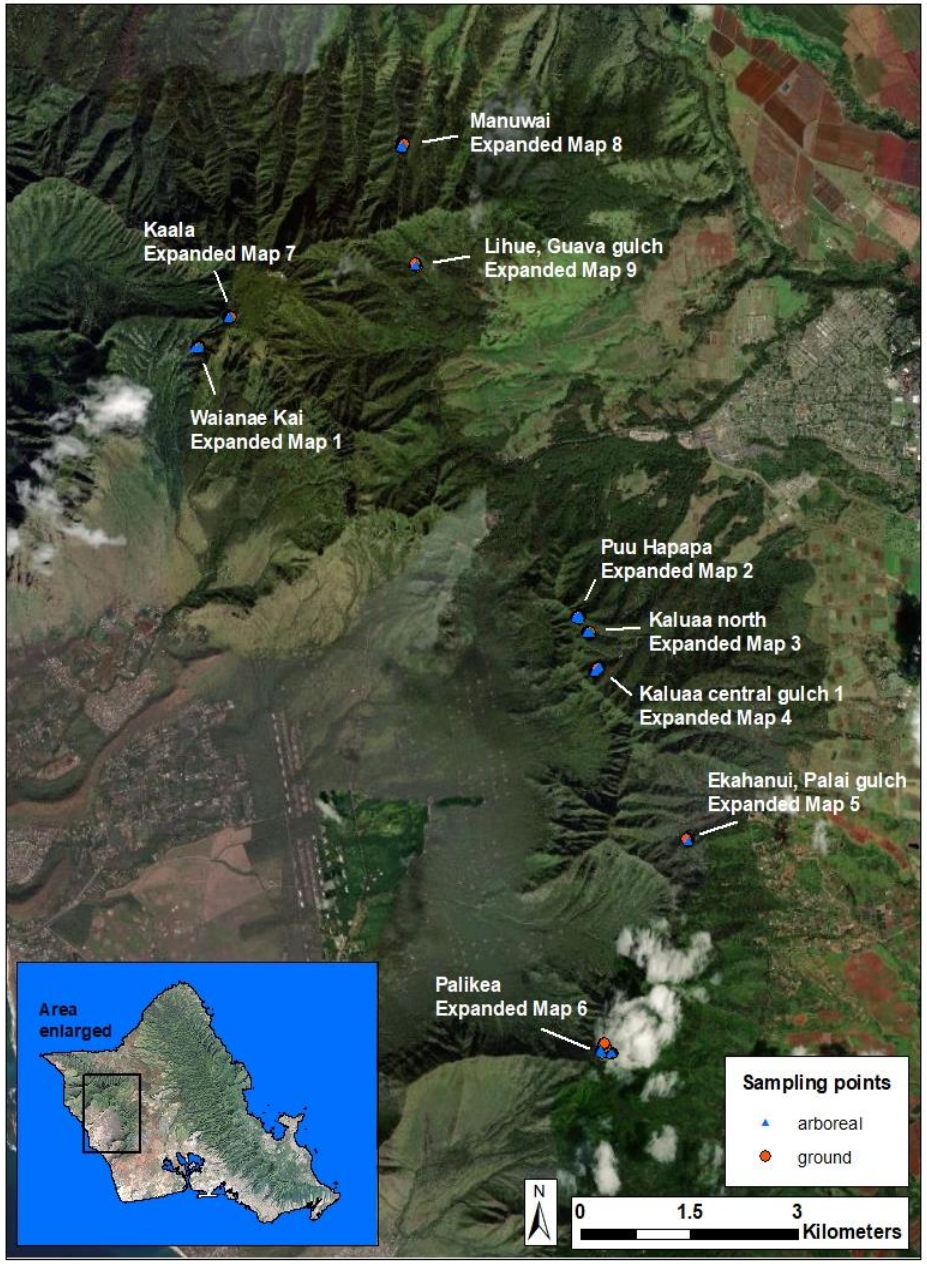
Dillingham Military Reservation



- 9 ant species
- Both ground and arboreal environments dominated by *Pheidole megacephala*
- *Ochetellus glaber* less common but can be abundant on coastal shrubs
- *Anoplolepis gracilipes* only occurs in one small section

I. Mapping ant distributions on DoD installations

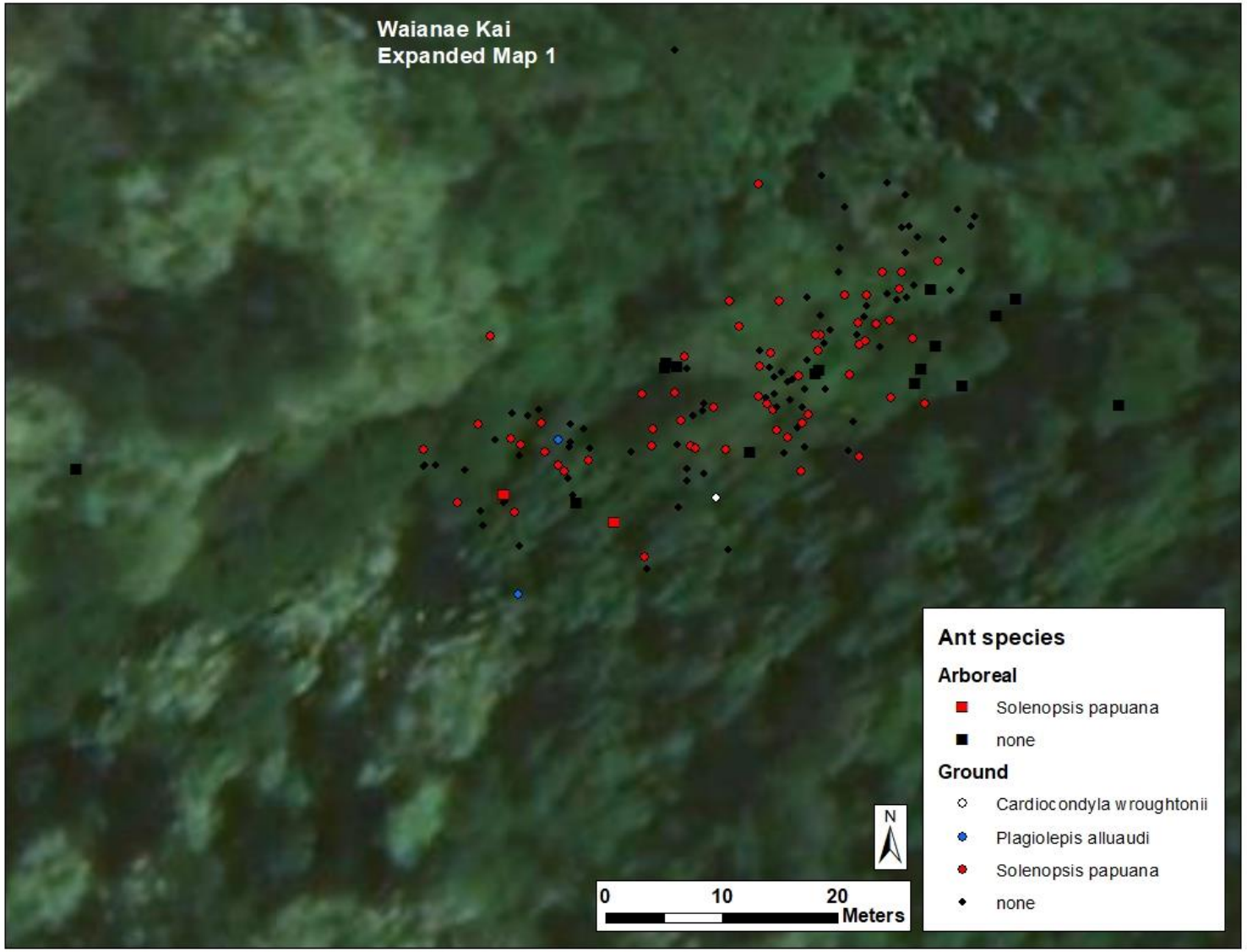


Schofield Barracks Army Base

9 picture-winged fly breeding sides in the Waianae Mountains

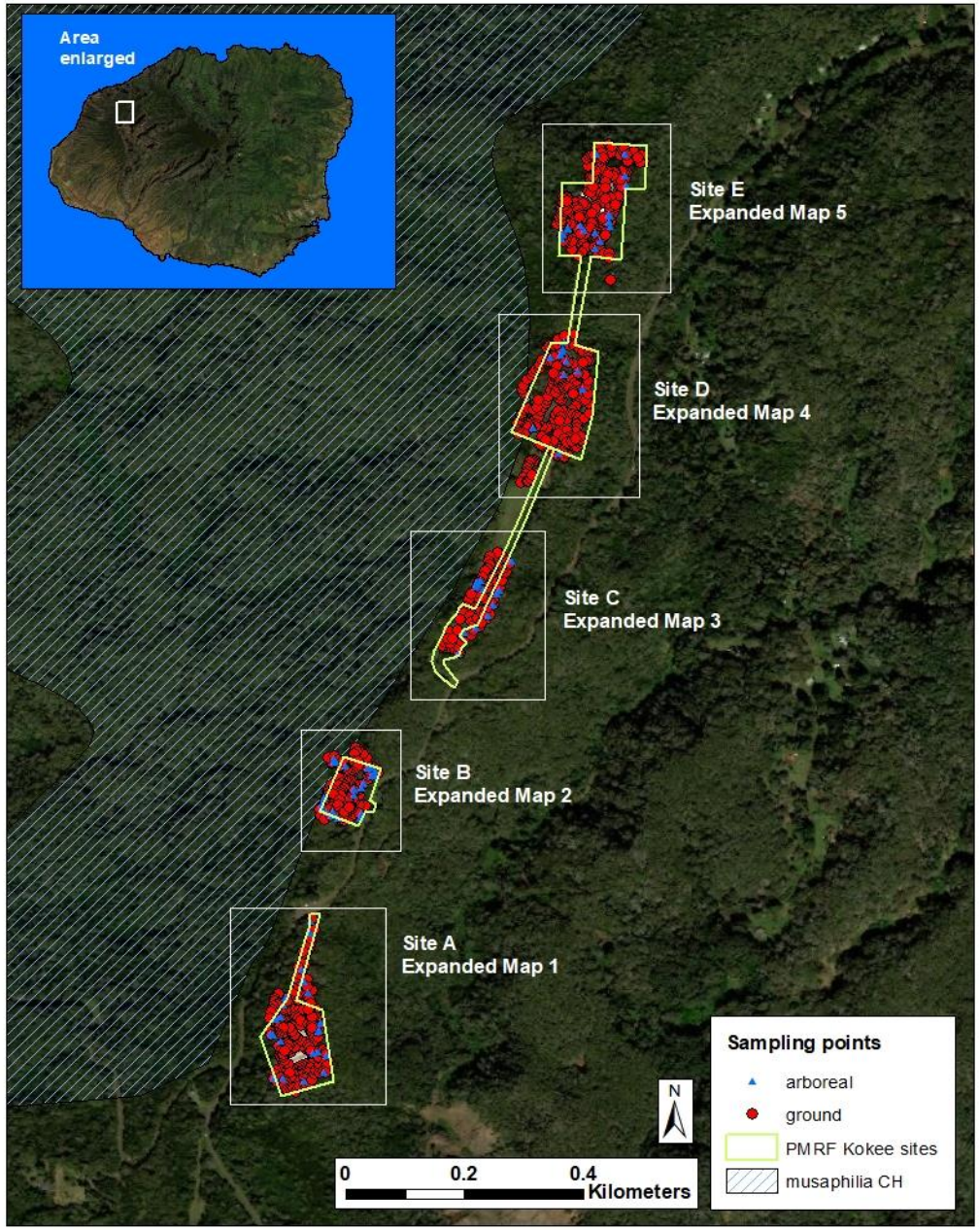
I. Mapping ant distributions on DoD installations

Schofield Barracks Army Base



- 8 ant species present at sites supporting host plants of *D. montgomeryi*, with the ant *S. papuana* the most common and abundant by far
- Only 3 ant species present at two sites supporting host plants of *D. substenoptera*, and ants were absent from most baits at both sites
- Only 4 ant species present at three sites supporting host plants of *D. obatai; S. papuana* was the most common and abundant ant at each site, but *Plagiolepis alluaudi* was also relatively common at these sites

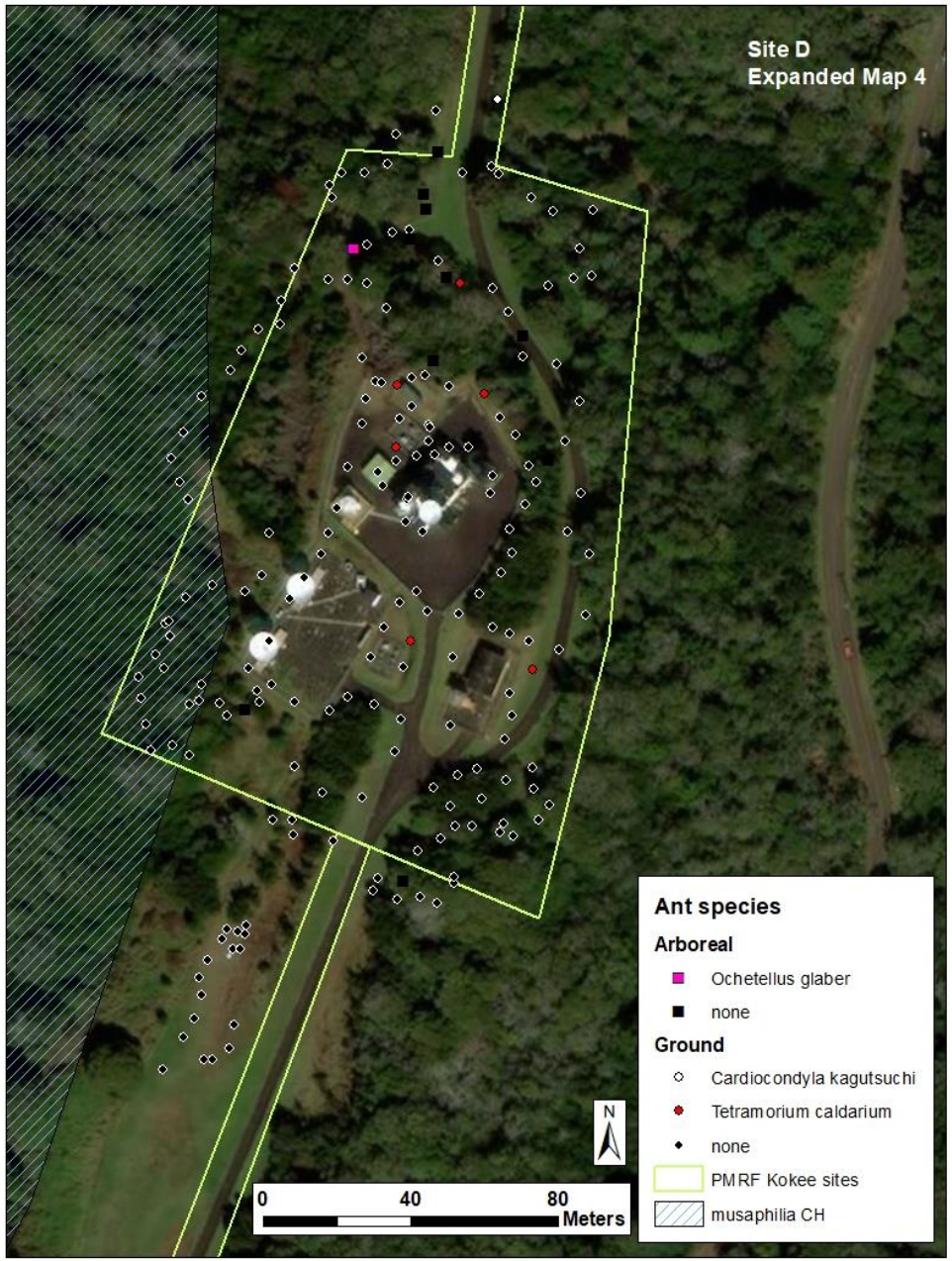
I. Mapping ant distributions on DoD installations



Pacific Missile Range Facility

5 leased parcels in Kokee State Park overlap with or abut picture-winged fly critical habitat

I. Mapping ant distributions on DoD installations



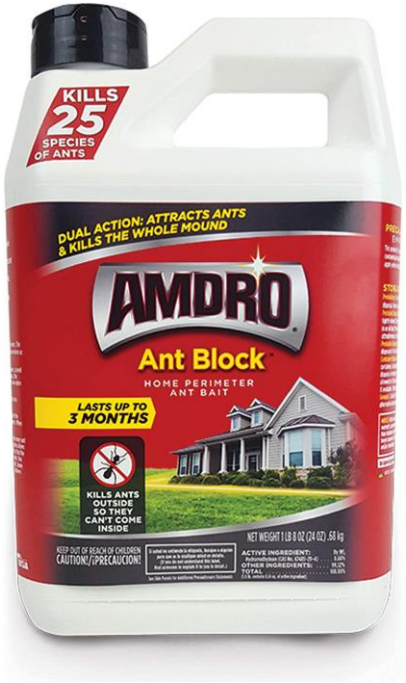
Pacific Missile Range Facility

- 8 ant species present across the five sites
- All of these species were relatively uncommon: ~80% of baits attracted no ants, especially those placed under forest canopy
- Ants were detected in only 3 of 93 baits placed on *Acacia koa*, the host plant for *D. musaphilia*
- Several problematic species, like *P. megacephala* and *L. humile*, could be targeted for control or even local eradication to prevent the possibility of spread into surrounding forest

II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Fly emergence was 58% lower in control plots.

(or ~2.4 times higher in ant suppressed plots)

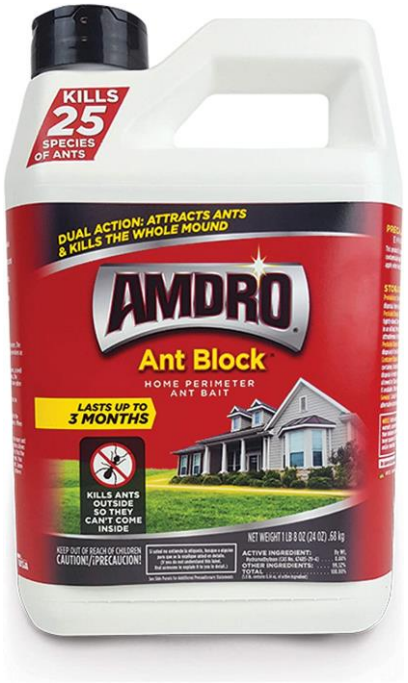


Krushelnycky et al. 2017. Biological Conservation 215: 254-259.

II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

How effective and safe is it to broadcast Amdro at picture-winged fly breeding sites?

- How long does ant suppression last?
- Are picture winged flies attracted to the bait?
- Are other native insects impacted?



II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

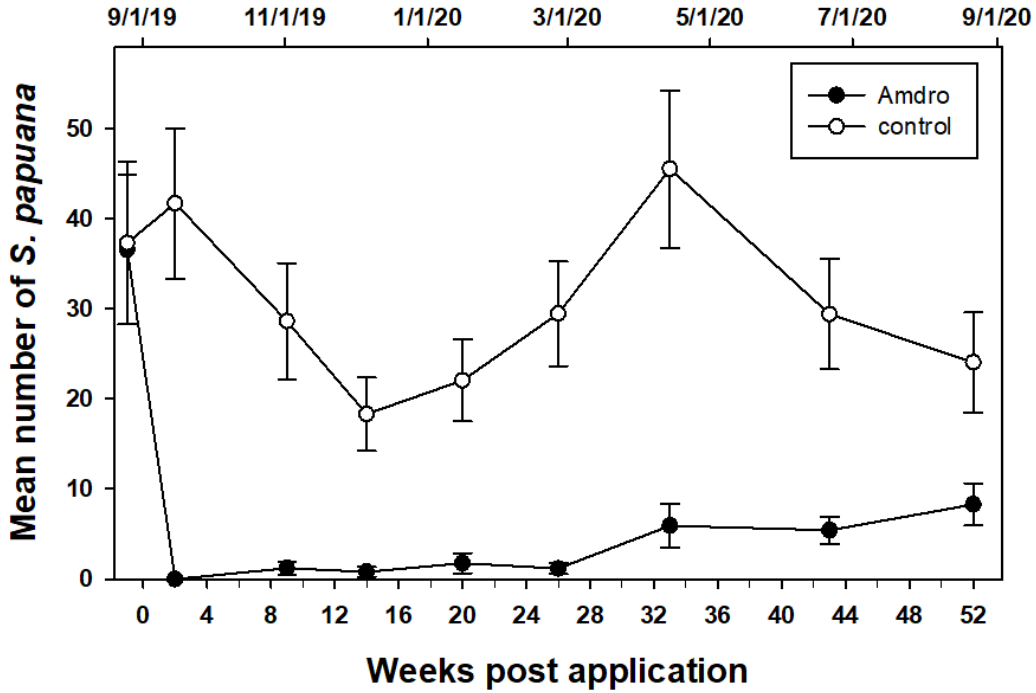
Efficacy and non-target impacts of Amdro broadcast on arthropod communities

- 7 pairs of 20 x 20 m plots at Kahanahāiki, Pahole, Kalua‘a
- Monitored ant abundances monthly using bait cards
- Sampled ground fauna with pitfalls and leaf litter extraction pre-treatment, then 2 weeks and 6 months post treatment

II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Efficacy for controlling *S. papuana*

- A single broadcast application of Amdro strongly suppressed *S. papuana* for about 6 months
- Ant numbers increased somewhat subsequently, but remained relatively low for at least a year



II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Non-target effects on ground-dwelling invertebrate communities

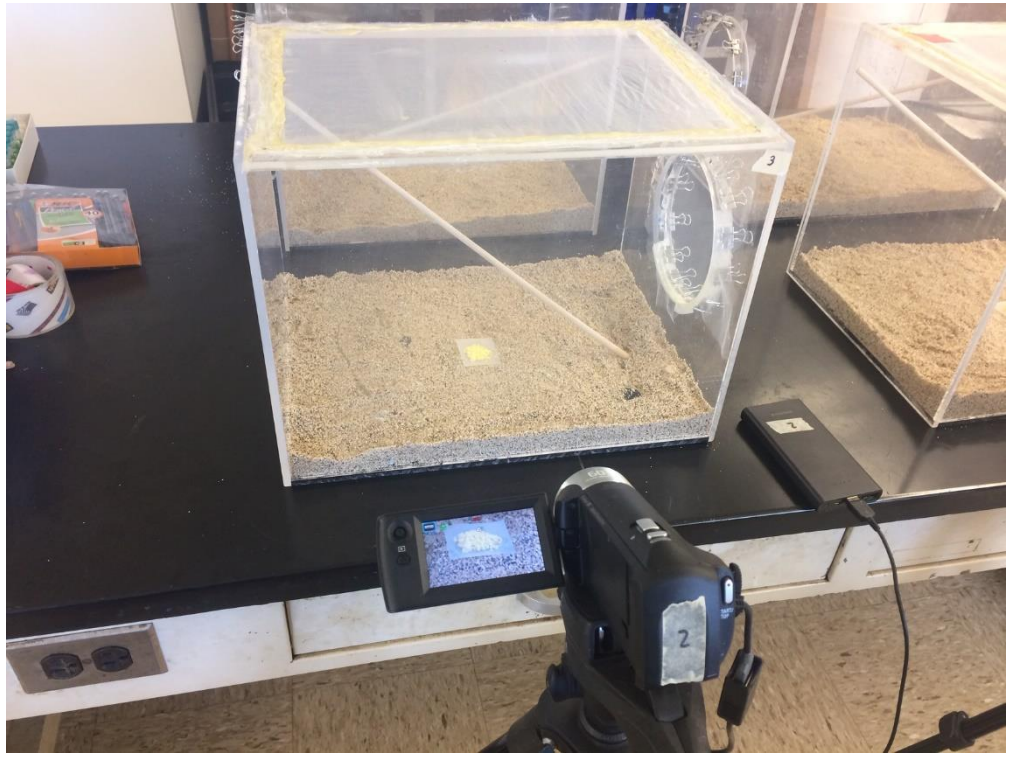
- 91,956 arthropods captured in pitfall and leaf litter sampling and sorted
- Invertebrate abundances did not significantly decrease in Amdro plots relative to control plots at 2 weeks post treatment for any taxonomic group
- Similarly, no invertebrate groups decreased in abundance in Amdro plots at 6 months post-treatment
- Other ant species did not increase in abundance after suppression of *S. papuana*

Taxon	2 weeks			6 months		
	Amdro	control	p[1]	Amdro	control	p[1]
Acari	758.6 ± 315.3	715.1 ± 430.3	0.655	984.4 ± 702.7	680..0 ± 651.7	0.142
Amphipoda	-36.6 ± 33.6	-47.6 ± 29.1	0.441			
Araneae	0.8 ± 9.9	32.1 ± 13.0	0.159	-10.0 ± 7.5	-5.1 ± 12.0	0.406
Blattodea	-0.7 ± 0.5	0.0 ± 0.4	0.179	-0.3 ± 0.4	1.4 ± 1.4	0.645
Chilopoda	1.0 ± 0.8	-1.3 ± 0.7	0.072			
Coleoptera						
native	2.6 ± 2.2	4.3 ± 2.2	0.700			
Proterhinus spp.[2]	0.1 ± 0.9	0.4 ± 0.7	0.732			
introduced	3.4 ± 2.8	3.8 ± 3.5	0.898			
total	-12.7 ± 13.6	-9.6 ± 26.2	0.798			
Collembola	100.6 ± 70.4	116.7 ± 25.7	0.406	100.0 ± 78.7	32.4 ± 63.6	0.406
Dermaptera						
native	-3.1 ± 1.8	-10.3 ± 6.0	0.556			
introduced	-11.3 ± 2.5	-6.3 ± 3.6	0.336			
total	-14.4 ± 3.5	-16.6 ± 6.6	0.798			
Diplopoda	-13.3 ± 13.7	6.1 ± 10.9	0.224			
Diptera	2.1 ± 1.7	0.3 ± 2.9	1.000			
Hemiptera						
native	4.7 ± 5.4	-4.1 ± 1.2	0.043			
Nesidiorchestes hawaiiensis[3]	3.6 ± 5.0	-3.7 ± 2.6	0.062			
introduced	3.1 ± 2.7	3.4 ± 3.2	0.795			
total	8.3 ± 6.1	-0.4 ± 3.4	0.200			
Hymenoptera						
non-ant total	0.1 ± 0.4	-0.4 ± 0.8	0.395	-0.1 ± 0.6	-0.8 ± 0.5	0.554
Isopoda	223.3 ± 86.4	24.7 ± 93.7	0.180	336.6 ± 144.9	142.0 ± 122.1	0.338
Lepidoptera						
Hyposmocoma spp.[4]	0.4 ± 0.4	0.7 ± 0.6	0.385	-0.4 ± 0.4	-0.4 ± 0.6	0.793
total	-4.8 ± 3.9	5.3 ± 7.3	0.480	-26.8 ± 9.0	-52.3 ± 21.8	0.898
Orthoptera						
Laupala spp.[5]	-1.1 ± 1.0	-0.1 ± 0.5	0.205	-0.8 ± 1.0	1.6 ± 1.9	0.274
Psocoptera	106.4 ± 41.2	60.8 ± 18.7	0.371	-15.0 ± 4.8	-8.1 ± 4.8	0.949
Thysanoptera	22.8 ± 16.1	-48.0 ± 47.0	0.064	-17.1 ± 10.3	-86.3 ± 75.9	0.607
Arthropoda						
native	-22.3 ± 21.3	-22.1 ± 13.0	0.482			
introduced	-96.6 ± 63.0	-67.0 ± 40.6	0.794			
total	1060.1 ± 419.9	804.3 ± 478.4	0.482			
Gastropoda	6.0 ± 3.4	1.3 ± 0.3	0.321	7.0 ± 2.6	7.0 ± 2.1	0.334

II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Attraction of picture-winged flies to Amdro

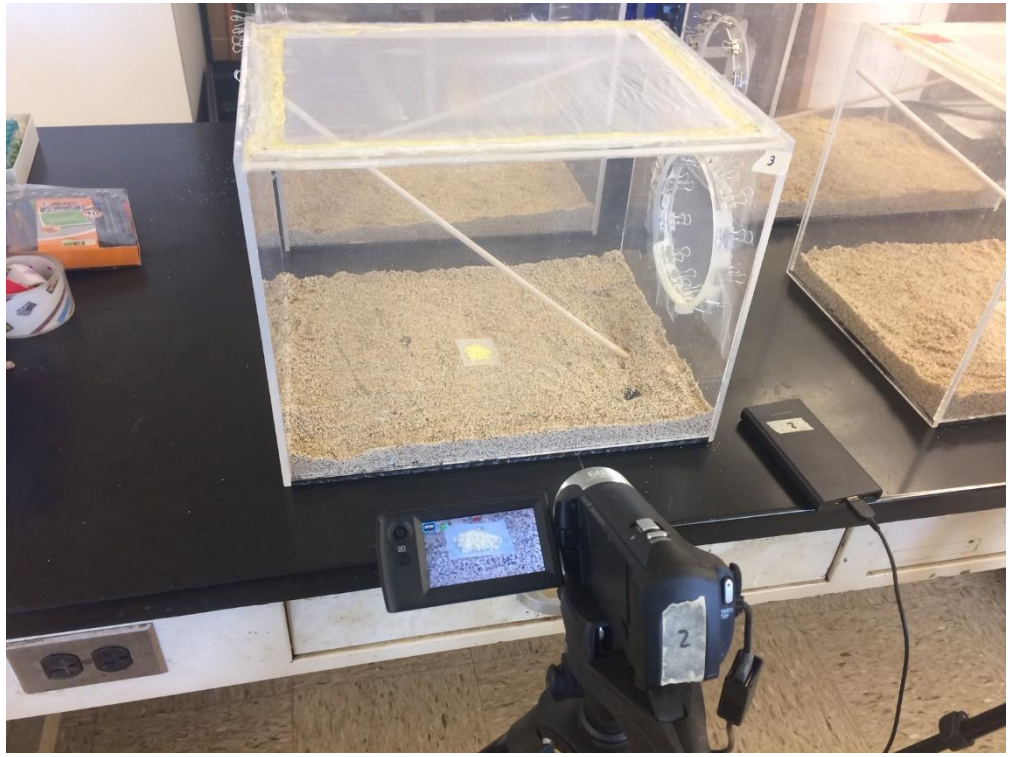
- Non-listed picture winged-flies placed in cages with Amdro bait, or in control cages without Amdro bait
- 45 flies belonging to three species were tested
- Feeding behavior filmed for 9 hours on each of first two days
- Survival monitored over 7 days



II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Attraction of picture-winged flies to Amdro

- Only 3 of 23 flies placed in Amdro cages were observed to approach the bait during the first two days
- Only 1 of these flies appeared to feed on the bait, for 34 seconds
- Clearly there was no strong attraction to the Amdro bait

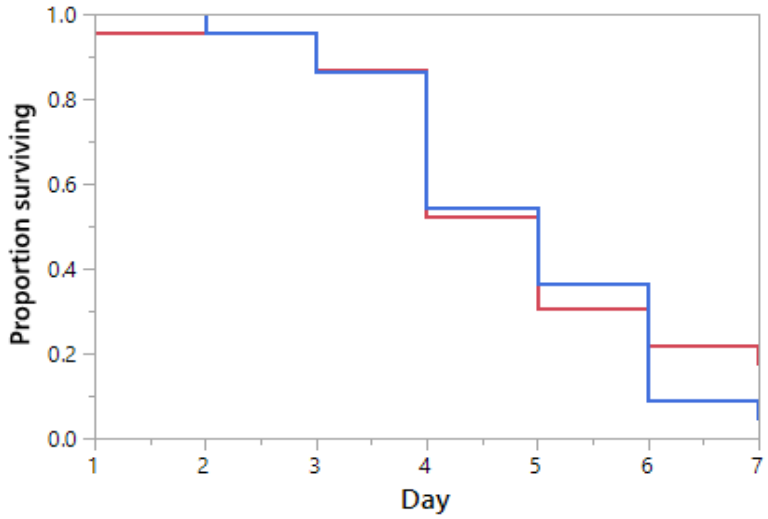


II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Attraction of picture-winged flies to Amdro

- No significant difference in time to death for flies in Amdro vs. control cages for each of three species

- Kaplan-Meier survival curves pooled across species show slightly higher survival in Amdro cages (red) compared to control cages (blue)

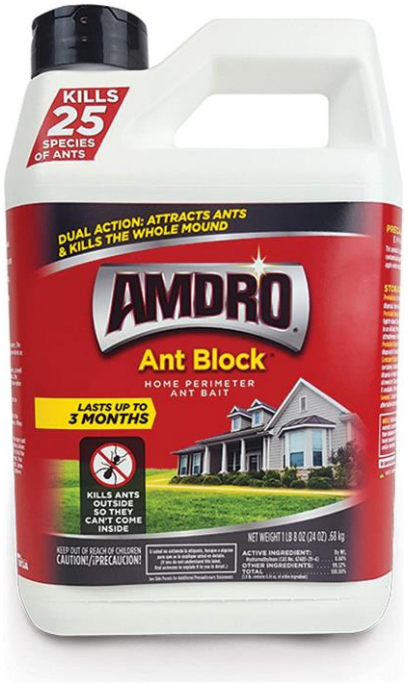


Species	Mean days to death ± SE (n)		Log-ranked chi-square	p
	Amdro	Control		
Drosophila ambochila	4.4 ± 0.4 (9)	4.0 ± 0.5 (8)	0.686	0.408
Drosophila crucigera	5.5 ± 0.7 (6)	4.8 ± 0.4 (6)	2.02	0.155
Drosophila punalua	4.5 ± 0.6 (8)	5.6 ± 0.4 (8)	0.761	0.383
combined	4.8 ± 0.3 (23)	4.8 ± 0.3 (22)	0.302	0.583

II. Efficacy and non-target risk for controlling ants attracted to oil-based baits

Overall conclusions

- Amdro has some of the broadest label language of any ant bait products registered in Hawai‘i, including forest use.
- Is very effective in suppressing *S. papuana* over a long time period.
- No strong evidence for severe impacts on native invert communities when broadcast in localized areas, such as around picture-winged fly host plants.
- No evidence for attraction to Amdro by picture-winged flies.
- Should be safe and effective for managing *S. papuana* at picture-winged fly breeding sites.



III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

- Many ant species strongly attracted to nectar, honeydew, and other sugar sources
- Sugar water-based baits can be highly effective, but require bait stations that are expensive, labor-intensive, and impractical at larger scales
- Polyacrylamide “hydrogels” have recently been used to transform liquid baits into solid, granular baits that can be broadcast
- Have been used in experimental eradication efforts in California Channel Islands, Johnston Atoll, Australia

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

- Polyacrylamide hydrogels are not biodegradable, so two alternatives have been developed or tested: alginate hydrogels and textured vegetable protein (TVP)

- None of these are registered for use with any pesticide product in the US, and additional research likely needed for regulatory approval

Polyacrylamide (Poly)

Alginate (Alg)

Textured vegetable protein (TVP)

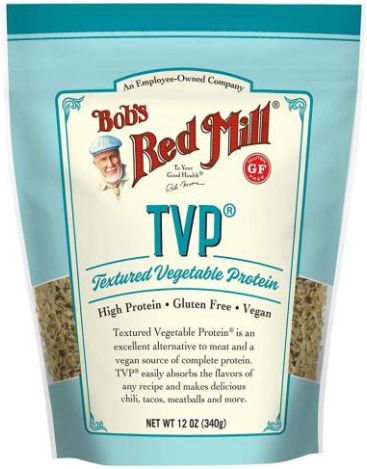
III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

Focused on several different questions surrounding use of “Water-storing granules” (WSG)

1. Drying rates
2. Palatability
3. Repellency of active ingredients
4. Efficacy of bait formulations
5. Non-target species attraction
6. Indirect non-target exposure via pesticide residues

Polyacrylamide (Poly)

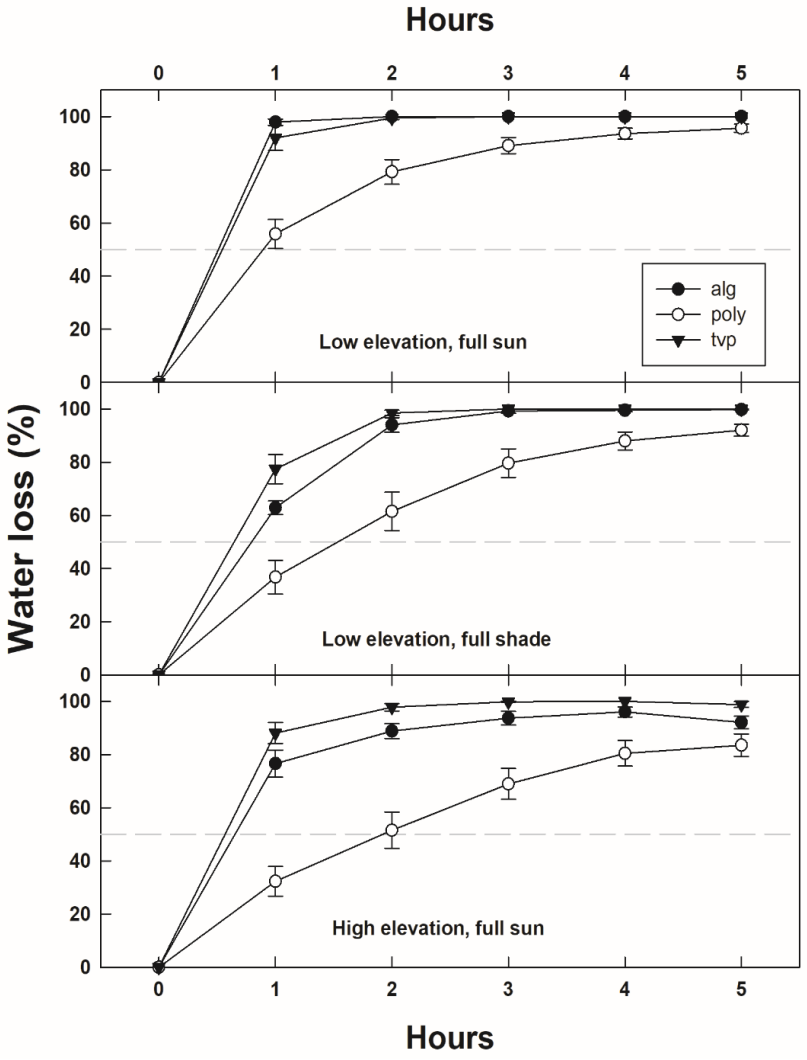
Alginate (Alg)

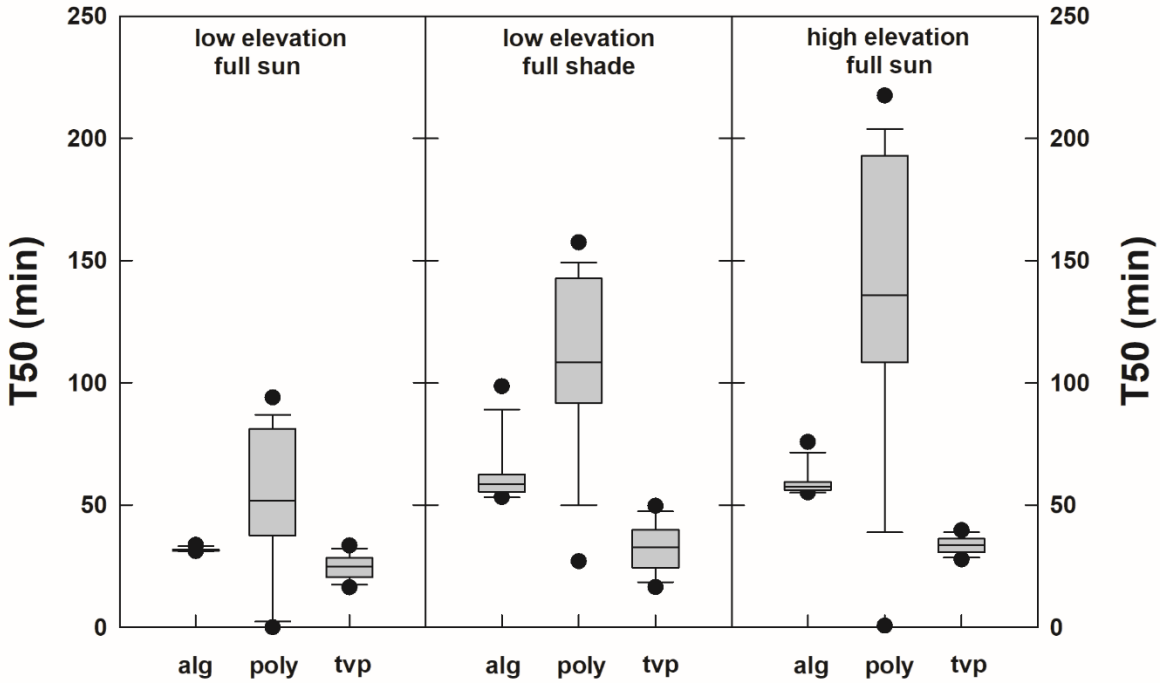


Textured vegetable protein (TVP)

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

1. Drying rates





III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

2. Palatability

- Conducted choice and no-choice trials with three ant species
- No strong differences in attractiveness among the three WSG types

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

3. Repellency of active ingredients

- Conducted choice trials with three ant species and three active ingredients: thiamethoxam, dinotefuran, indoxacarb

- Different ant species are sensitive to different AI's:
  - Yellow Crazy Ant found thiamethoxam repellant
  - Argentine Ant found dinotefuran repellent
  - Little Fire Ant found thiamethoxam repellent

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

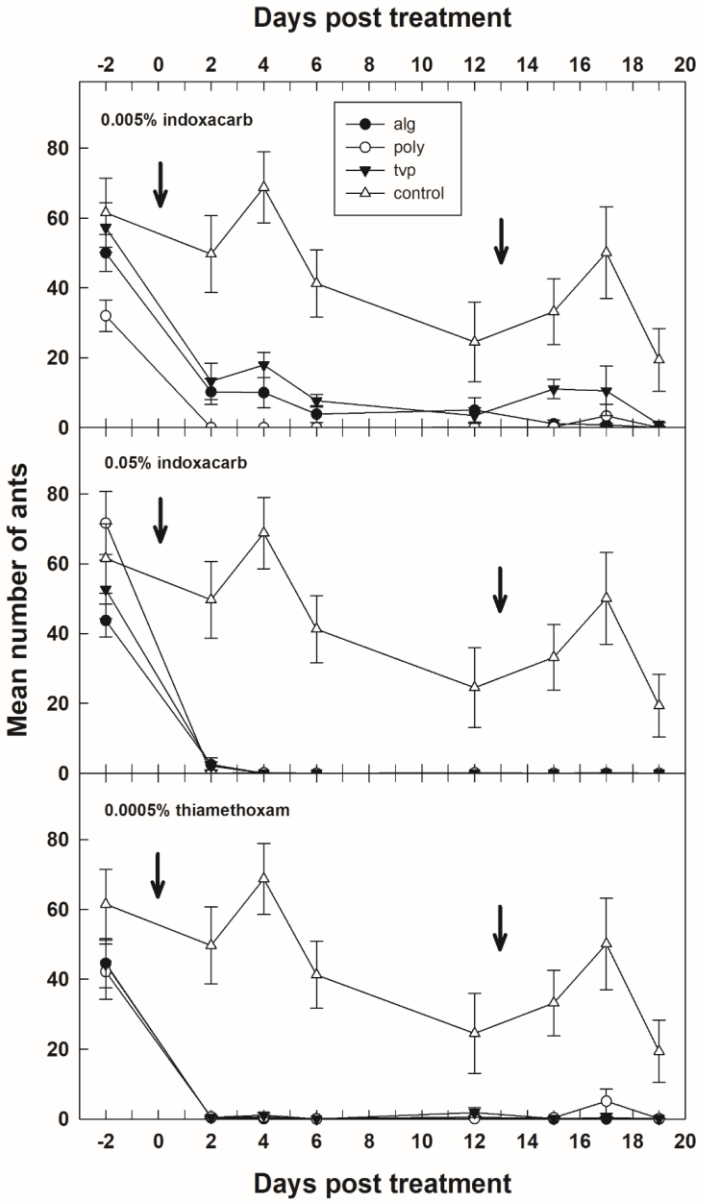
4. Efficacy of bait formulations

- Tested most promising formulations on two ant species: Yellow Crazy Ant and Argentine Ant
- Broadcast WSG in 25 x 25 m field plots in a series of tests to determine the most effective AI's and concentrations for each ant

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

4. Efficacy of bait formulations

- Yellow Crazy Ant controlled well with dinotefuran at 0.005% to 0.05% concentration; indoxacarb formulations less effective
- Argentine Ant controlled well with 0.0005% thiamethoxam and with 0.05% indoxacarb
- All three WSG carriers were effective (polyacrylamide, alginate, TVP)



III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

5. Non-target species attraction

- Focused on insects and especially pollinating species
- Assessed using two methods: video observations and bait marking

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

5. Non-target species attraction: video observation

Baits on ground (>384 hrs)

Taxon	Alginate	Poly.	TVP	Total
Acari Total	5	2	0	7
Araneae Total	0	4	1	5
Chilopoda Total	0	0	1	1
Isopoda Total	0	1	0	1
Collembola Total	1	0	3	4
Diptera Total	9	21	55	85
Sarcophagidae	1	11	30	42
Syrphidae	3	2	0	5
Other/unknown	5	8	25	38
Hymenoptera Total	6	3	14	23
Bees Total (Apidae or Colletidae)	2	0	3	5
Ceratina dentipes	1	0	3	4
Hylaeus volatilis	1	0	0	1
Sphecidae Total	0	0	1	1
Tachysphex apicalis	0	0	1	1
Parasitoids Total	4	3	10	17
Unknown Total	2	2	2	6
Grand Total	23	33	76	132

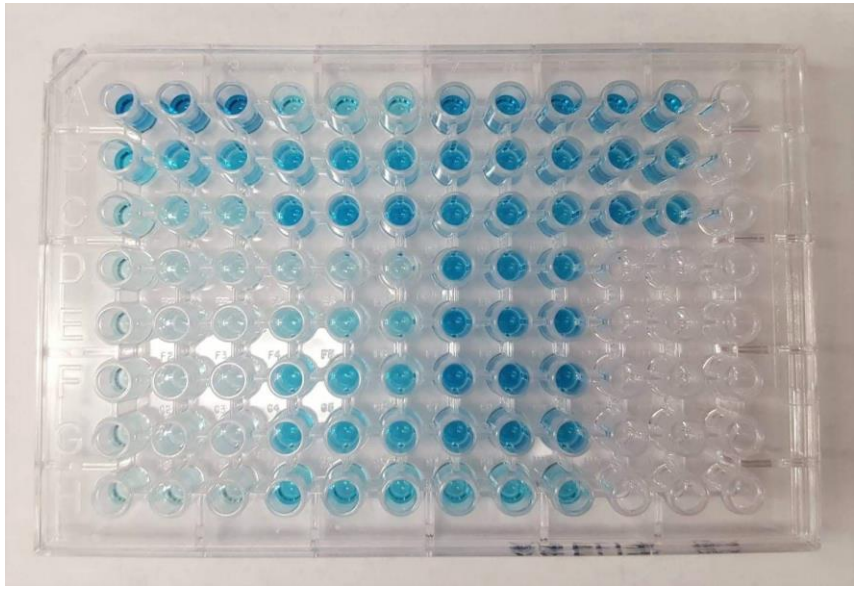
Baits near flowers (>307 hrs)

Taxon	Alginate	Poly.	TVP	Total
Araneae Total	0	4	1	5
Diptera Total	8	3	6	17
Syrphidae	5	0	2	7
Other/unknown	3	3	4	10
Hemiptera Total	0	0	2	2
Miridae	0	0	2	2
Hymenoptera Total	113	115	68	296
Bees Total (Apidae or Colletidae)	98	111	61	270
Apis mellifera	73	83	45	201
Hylaeus spp. (native)	3	12	6	21
Hylaeus strenuus (non-native)	22	16	10	48
Vespidae Total	14	4	7	25
Pachodynerus nasidens	1	2	0	3
Polistes aurifer	13	2	7	22
Parasitoids Total	1	0	0	1
Lepidoptera Total	8	32	33	73
Crambidae	8	32	33	73
Orthoptera Total	0	1	0	1
Tettigoniidae Total	0	1	0	1
Elimaea punctifera	0	1	0	1
Grand Total	129	155	110	394

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

5. Non-target species attraction: protein marking

- Spiked baits with 2% rabbit serum
- Broadcast baits in 10 x 10 m plots (n = 18)
- Netted flying insects in plots for ~3-4 hrs after broadcast, focusing on bees and other pollinators (captured 441 insects total)
- Screened captured insects for presence of rabbit IgG protein using sandwich ELISA



III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

5. Non-target species attraction: protein marking

- 9.3% of flying insects were marked
- Bees had a low rate of marking (6.7% of honeybees, 1.4% of native yellow-faced bees)
- Suggests that most pollinators do not often encounter WSG granules when broadcast
- Several groups had much higher rates of marking (46.9% of a non-native wasp species, 20.4% of a native fruit fly), indicating that they probably actively sought out granules

Taxon	Alginate % marked (n)	Poly. % marked (n)	TVP % marked (n)	All WSG % marked (n)
Diptera Total	14.3 (14)	5.9 (17)	15.4 (13)	11.4 (44)
Calliphoridae Total	0 (1)	0 (1)	0 (1)	0 (3)
Eucalliphora latifrons	0 (1)	0 (1)		0 (2)
Gonia longipulvilli			0 (1)	0 (1)
Muscidae Total		0 (1)	0 (1)	0 (2)
Muscidae sp.		0 (1)	0 (1)	0 (2)
Pterophoridae Total	0 (3)	0 (3)	0 (4)	0 (10)
Stenoptilodes littoralis rhynchophora	0 (3)	0 (3)	0 (4)	0 (10)
Sarcophagidae Total	33.3 (3)	0 (2)	0 (1)	16.7 (6)
Blaesoxipha plinthopyga	50.0 (2)	0 (1)	0 (1)	25.0 (4)
Ravinia anandra		0 (1)		0 (1)
Sarcophaga albiceps	0 (1)			0 (1)
Syrphidae Total	0 (3)	0 (3)	0 (2)	0 (8)
Allograpta exotica	0 (2)	0 (1)	0 (1)	0 (4)
Simosyrphus grandicornis	0 (1)	0 (2)	0 (1)	0 (4)
Tephritidae Total	25.0 (4)	14.3 (7)	50.0 (4)	26.7 (15)
Bactrocera dorsalis			100 (1)	100 (1)
*Trupanea cratericola	25.0 (4)	14.3 (7)	33.3 (3)	21.4 (14)
Hemiptera Total		0 (1)		0 (1)
Lygaeidae Total		0 (1)		0 (1)
*Nysius sp.nr. abnormis		0 (1)		0 (1)
Hymenoptera Total	30.2 (63)	6.3 (79)	9.1 (77)	14.2 (219)
Apidae Total	8.3 (12)	0 (27)	9.4 (32)	5.6 (71)
Apis mellifera	9.1 (11)	0 (16)	11.1 (18)	6.7 (45)
Ceratina dentipes		0 (1)		0 (1)
Ceratina smaragdula	0 (1)	0 (10)	7.1 (14)	4.0 (25)
Colletidae Total	0 (20)	0 (31)	5.3 (19)	1.4 (70)
*Hylaeus nivicola	0 (17)	0 (22)	6.7 (15)	1.8 (54)
*Hylaeus volatilis	0 (3)	0 (9)	0 (4)	0 (16)
Halictidae Total	0 (3)	0 (7)	0 (3)	0 (13)
Lasioglossum imbrex	0 (2)	0 (1)		0 (3)
Lasioglossum microlepoides	0 (1)	0 (6)	0 (3)	0 (10)
Ichneumonidae Total		0 (2)	0 (4)	0 (6)
Calliephialtes grapholithae			0 (1)	0 (1)
Diadegma blackburni		0 (2)	0 (3)	0 (5)

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

6. Indirect non-target exposure via pesticide residues

- Collected soil, plant tissue and water samples before bait broadcasts in the 25 x 25 m efficacy plots, and then at intervals up to 90 days later
- Sent samples to Dr. Daniel Snow of the Water Sciences Laboratory at the University of Nebraska for analysis
- Samples analyzed with state-of-the-art Xevo TQS triple quadrupole mass spectrometer

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

6. Indirect non-target exposure via pesticide residues

- Residues of the two neonicotinoid pesticides (dinotefuran and thiamethoxam) were generally relatively low in and around the field efficacy plots.
- Neonic residues tended to be highest in plant tissues, and were higher when bait formulations used higher concentrations of the AI.
- The highest neonic plant tissue residues, on the order of <10 ppb, are much lower than values reported from direct neonicotinoid application methods.
- These concentrations of low risk to honey bees on acute toxicity basis, but are within the range of values suggested to cause sublethal effects on bees.

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

6. Indirect non-target exposure via pesticide residues

- Neonic residues in soils tended to be lower than in plant tissues, all <2 ppb.
- Neonic residues in freshwater and seawater were detectable but very low, <15 ppt.

III. Efficacy and non-target risk for controlling ants attracted to sugar water-based baits

6. Indirect non-target exposure via pesticide residues

- Contrary to expectations, residues of indoxacarb were higher than the neonics in plant tissues (up to 150 ppb), even after accounting for the higher concentrations used.
- Indoxacarb residues in soil were lower, <8 ppb.
- Indoxacarb residues in freshwater and seawater were very low, <4 ppt.
- Risk to honey bees from indoxarb residues more poorly known. Residues measured are probably low risk on an acute toxicity basis, but more difficult to predict risk of sublethal effects.

Thank you!

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