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Technical Report 156

SURVEY FOR ANTS ON THE ISLAND OF MAUI, HAWAII, WITH EMPHASIS ON THE LITTLE FIRE ANT (WASMANNIA AUROPUNCTATA)

May 2008

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Image of *Wasmannia auropunctata* by April Noble (AntWeb)

ABSTRACT

The little fire ant (LFA), *Wasmannia auropunctata*, is an aggressive pest ant with a painful sting that has spread to many parts of the world through human commerce. In the State of Hawaii, LFA had been intercepted previously as early as 1930, but only recently, in 1999, were established populations found in the Puna District, on the island of Hawaii (Big Island), occupying residential and agricultural sites, such as fruit orchards and plant nurseries. A single population was found on Kauai in 1999, but it has been contained and nearly eradicated. However, on Hawaii island, LFA is now well established in the Puna/Hilo area, with at least 50 sites covering at least several hundred acres. Even though nursery shipments leaving Hilo are checked for LFA by inspectors of the Hawaii Department of Agriculture, it is likely that LFA-infested shipments have reached Maui. This study surveyed portions of the island of Maui for ants, with a main goal of finding populations of LFA. Since much of the nursery material sent from Hawaii to Maui is promptly planted in new developments, searches were focused on newly developed / landscaped areas. During the survey, over 18,000 ants were collected on 4,300 peanut butter baited chopsticks at 360 sites, resulting in 823 locations with 23 ant species but no LFA. The big-headed ant (*Pheidole megacephala*) was by far the most abundant ant encountered in the survey and present at 55% of the sampling sites. However, since not all ant species are equally attracted to the peanut butter bait used in this survey, the relative abundance of ant species encountered may be biased, and 12 species of ants previously recorded for Maui were not collected in the survey.

INTRODUCTION

This survey targets the little fire ant, *Wasmannia auropunctata*, on the island of Maui. The reason for this survey is put into good perspective by excerpts from a brochure prepared for release on the Big Island of Hawaii in 2006 (CTAHR 2006):

> Little fire ants (LFA) are stinging ants that are new to Hawaii, and spreading. They are transported to new sites in potted plants and on other plant materials or rubbish.
>
> These tiny ants tend to get under your clothes and can get in your eyes. Initially their sting hurts and burns strongly. It usually causes intense itching that can last for two weeks or more. LFA stings are also known to harm animals, including pets and livestock; multiple stings in the eyes can cause blindness in pets or even the death of newly born small animals.
>
> The ants climb up into plants of all sizes, including trees. They drop off easily when the plants are disturbed, and they can rain down on you in large numbers when you are pruning branches, harvesting fruit, or picking flowers. Some orchard workers in East Hawaii have quit their jobs because of this. In the Galapagos Islands, when LFA populations are large, workers are prevented from harvesting coffee.
>
> A heavy infestation can make a property difficult to use commercially or enjoy recreationally. Casual dress is best avoided where LFA have taken hold—gloves, boots, and full body covering are needed in severely infested areas, where any contact with foliage, including sitting on lawns, can invite a sting. An LFA infestation is a "disclosure issue" in property sales.
>
> The little fire ant is native to Central and South America, but it has spread around the Pacific. It was first noticed in Hawaii in 1999 at Hawaiian Paradise Park in Puna. Although the Hawaii Department of Agriculture worked to contain the initial infestations, the ant had already been spread, inadvertently, from infested plant nurseries.
>
> Currently there are about 50 known LFA infestations in East Hawaii, one on Kauai, and probably many more on Hawaii that have yet to be discovered and reported. The Kauai LFA population appears to have been [nearly] eradicated, but monitoring continues. On Hawaii, limited agency resources and personnel, the few registered pesticide options, and continuing spread of the ants on infested plant material make it virtually impossible to have a wide-scale government program sufficient to eradicate this pest. People who own or live on the lands that LFA have infested must be willing to put serious, sustained effort into controlling them.

LFA has not yet been found on Hawaiian islands other than Hawaii and Kauai. However, inter-island trade of potted plants and other materials presents the opportunity for LFA to be transported from one island to another. The primary objective of this study was to locate small populations of LFA on Maui that could potentially be removed before becoming well established. A secondary objective, as it was likely that no LFA would be detected on Maui based on work done in previous surveys, was to create distribution maps for all ant species collected during the study. The survey used peanut butter baited chopsticks to attract ants, which were then collected and identified. This survey differed from previous surveys by looking at a broad range of locations, with a main emphasis on new developments. In the end, no LFA were found on Maui, but 20+ species of ants were detected and mapped.

SPREAD, BIOLOGY, AND IMPACTS OF LFA ELSEWHERE

In recent years, the LFA has emerged as a major exotic pest that "could easily be in the early phases of a pantropical explosion" (Deyrup 1991, cited by Wetterer and Porter 2003). Through human commerce and trade, this tiny (ca. 1.5mm in length) stinging ant has spread throughout tropical regions of the world including West Africa, islands of the Caribbean, Florida, and islands of the Pacific, including Galápagos, New Caledonia, Solomon Islands, Vanuatu, Tahiti, and Hawaii (Wetterer 2006). An extra-tropical invasion occurred in the Jordan Valley of Israel (north to 32° 43' N) several years ago, presumably on imported on logs from Gabon in West Africa (Vonshak *et al.* 2006, unpublished). Previously the northernmost site of LFA establishment was considered to be a location in Bermuda at 32° 20' N (Wetterer and Porter 2003). The area invaded in Florida is south of 30° N.

Invasive ant species have certain characteristics that make them more likely to invade new areas and more likely to succeed once they arrive. LFA have generalist feeding habits, superficial nests, high colony mobility, multiple queens in a colony, colony budding, low intraspecific aggression, high aggression toward other species, and tend nectaries of plants and insects in the order Homoptera (Brandao and Paiva 1994, Passera 1994). They are able to establish and nest in a variety of conditions, from wet to dry habitat in open or shaded areas, under rocks, in or under logs, in plant debris, or in trees (Deyrup *et al.* 2000). They have a remarkable, recently discovered, ability to react adaptively for dispersal when their many-queened colonies are disturbed - they are behaviorally programmed to reorganize in units of a single queen with 5-6 workers on her back - potentially providing the means of establishing a new colony (Feitosa 2007).

LFA pose a major nuisance to humans and other vertebrates, both domestic and native, because of their powerful sting and aggressive nature. LFA often sting humans in homes and agricultural settings, with reports from virtually throughout the range of the ant (Wetterer and Porter 2003). In native range in Brazil, LFA were one of the most commonly found ant species in cacao plantations, forestry plantations, hospitals, and in homes (Bueno and Fowler 1994, Delabie *et al.* 1995, Wetterer and Porter 2003). In Guadalcanal, Solomon Islands, local residents reported that their dogs were all gradually

blinded by the LFA's venom and rarely lived more than five years; chickens were also blinded (Wetterer 1997). In Gabon, in areas of high LFA density, domestic cats, leopards, elephants, and river hogs show evidence of corneal clouding and blindness, apparently from stings of LFA (Wetterer *et al.* 1999; Walsh *et al.* 2004). There is also evidence of young turtles and birds being negatively affected by LFA in Galápagos (Roque-Albelo and Causton 1999).

Silberglied (1972) found that LFA's "impact upon the Galapagos terrestrial invertebrate fauna appears to be the most serious of any introduced animal," a conclusion confirmed by many subsequent studies. Clark *et al.* (1982) found that *W. auropunctata* "either exterminates or reduces to very low density all sympatric species" of ants. Lubin (1984) found that areas with *W. auropunctata* present had not only lower diversity and density of other ants, but also lower densities of other insects, as well as scorpions and spiders, though honeydew-producing Homoptera increased. Negative effects of LFA on over 30 native ant species in New Caledonia are dramatic (Le Breton *et al.* 2005). In ant-rich (79 native ant spp.) forest and savannah of Lopé National Park, Gabon, in continental Africa, LFA were shown to sharply reduce (by 20x in areas invaded 10 years earlier) numbers of native ant species present (Walker 2006).

ANTS IN HAWAII AND THE THREAT OF ADDITIONAL INTRODUCTIONS

About 51 species of ants have established in Hawaii, although a few of these have not been collected in many decades and possibly no longer occur (see Appendix 1 in Krushelnycky *et al.* 2005b; Neil Reimer pers. comm.). Hawaii's 51 species surpasses the known number of ant species introduced to nearly every other biogeographic region of the world (McGlynn 1999). Prior to human contact, Hawaii had no ant species (Wilson and Taylor 1967); all current species have arrived with human assistance, with six continents as well as oceanic islands represented among the sources of the modern Hawaiian ant fauna (McGlynn 1999, Krushelnycky *et al.* 2005b).

Reimer *et al.* (1990) have provided a comprehensive review of ants as pests in Hawaii, and Reimer (1994) and Krushelnycky *et al.* (2005b) review ant threats to native biodiversity. The most dominant and damaging species to date in Hawaii are believed to be the big-headed ant (*Pheidole megacephala*), the Argentine ant (*Linepithema humile*), the long-legged or crazy ant (*Anoplolepis gracilipes*), and the tropical fire ant (*Solenopsis geminata*). These four are among the six most disruptive ant invaders in the world, along with the red imported fire ant or RIFA (*Solenopsis invicta*) and LFA (*Wasmannia auropunctata*) (Holway *et al.* 2002). Hawaii already has five of the six and is immensely concerned about potential establishment of *S. invicta*, which reached California from the southern U.S. in 1998 and now occupies much of the southwestern Pacific Rim (Krushelnycky *et al.* 2005b). RIFA and LFA are the most feared potential ant introductions for the island of Maui and other Hawaii islands.

Island of Hawaii

LFA had been previously intercepted but not established in the Hawaiian Islands as early as 1930 (Swezey 1945). LFA was first found and reported in March 1999 in the Puna District on the island of Hawaii, but evidence suggests that it had been present in the area for at least four years before its discovery (Conant and Hirayama 2000). Before the end of 1999, three additional populations were discovered, one 20 acres in area (Conant *et al.* 2007). It was found that LFA were being dispersed by movement of infested plants. By 2002, there were 20 known infestations, and by 2004, there were 31 populations covering over 76 hectares (188 acres) (Krushelnycky *et al.* 2005b). As of February 2007, the invasion has occupied 50 sites and has occurred as high as 1500 ft elevation (Conant *et al*. 2007). Many of these infestation sites include nurseries, farms, and orchards. Nursery shipments leaving Hilo for other islands have been checked prior to shipment by baiting for LFA by inspectors of the Hawaii Department of Agriculture for several years, but to date there are no measures other than attempts at comprehensive public education for preventing within-island spread on Hawaii.

Island of Kauai

Months after LFA was discovered on the island of Hawaii in early 1999, a container of plants was shipped from an infested nursery to the island of Kauai (Null and Gunderson 2006). Suspecting that LFA could have been transported, HDOA personnel conducted a survey of the receiving property, located near Kilauea, Kauai, and confirmed their suspicions as LFA was found to be present (Null and Gunderson 2006).

An eradication project was initiated at the site and was thought to be successful as of 2000 (Null and Gunderson 2006). However, during monitoring in 2003 by the Kauai Invasive Species Committee (KISC), LFA was again found to be present and the area of infestation had spread to an adjacent property (Null and Gunderson 2006). Eradication efforts were resumed in 2004. To date, the site is monitored and treated twice yearly. It is believed that while eradication has not yet been achieved (probably because of colony survival in trees) the infestation is contained and has not yet spread to other areas.

From 2004-2006 an island wide survey was conducted on Kauai targeting nurseries, resorts, golf courses, and other areas known to have received shipments from infested areas of the island of Hawaii. To date, LFA has not been encountered at any other site on Kauai, other than the original site (Null and Gunderson 2006).

Island of Maui

To date, no LFA have been found to be established on the island of Maui. However, it is known that shipments from infested areas on the Big Island are being sent to Maui. For example, there was an item in the October 4, 2006, HDOA E-news as follows: “August 31 - Hilo inspectors used peanut butter bait sticks to detect little fire ants in two pallets containing 2,000 mondo grass plugs. The shipment, destined for Maui, was rejected.”

Because of the very significant potential for LFA invasion, surveys have been conducted on Maui to try to find small populations before they become widely established.

Previous LFA surveys on Maui (Figure 1) include work done by the Hawaii Department of Agriculture (HDOA), the U.S. Geological Survey (USGS), and the Maui Invasive Species Committee (MISC). None of these surveys have yet detected LFA on Maui.

Since 2001, HDOA has conducted annual surveys for LFA at Kahului Airport, Kahului Harbor, and other high risk sites. Additionally, certified nurseries are tested for LFA during the certification process.

In 2003, we (USGS) conducted a brief survey for LFA using methodology outlined by Conant and VanGelder (2003). Surveys focused on non-certified nurseries and locations with mature fish-tail palm (*Caryota* spp.) plantings.

In 2005, Maui Invasive Species Committee conducted a survey for LFA, by having students collect ants using methods outlined in the "Hoike o Haleakala" science curriculum, a multi-disciplinary, science-based environmental education curriculum designed to help sustain the native Hawaiian landscape and culture by helping students establish and deepen connections to the land and the culture it supports (HEAR 2003).

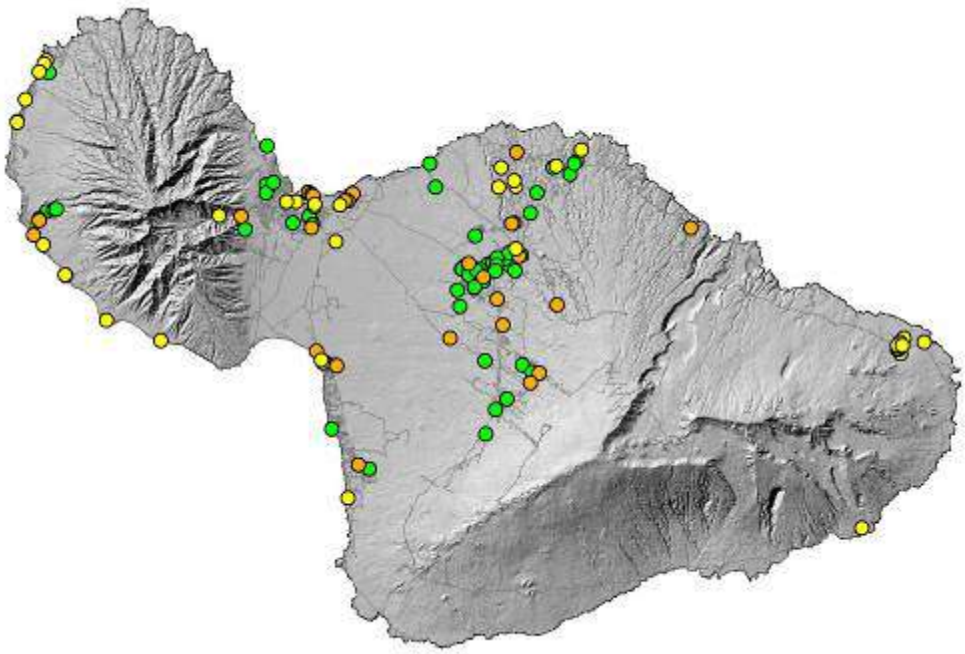

Figure 1. Map of 97 collection sites for previous Maui *Wasmannia* surveys. Includes work by USGS (yellow - 2003 survey), HDOA (orange - certified nurseries and ports), and MISC (green - Hoike program).

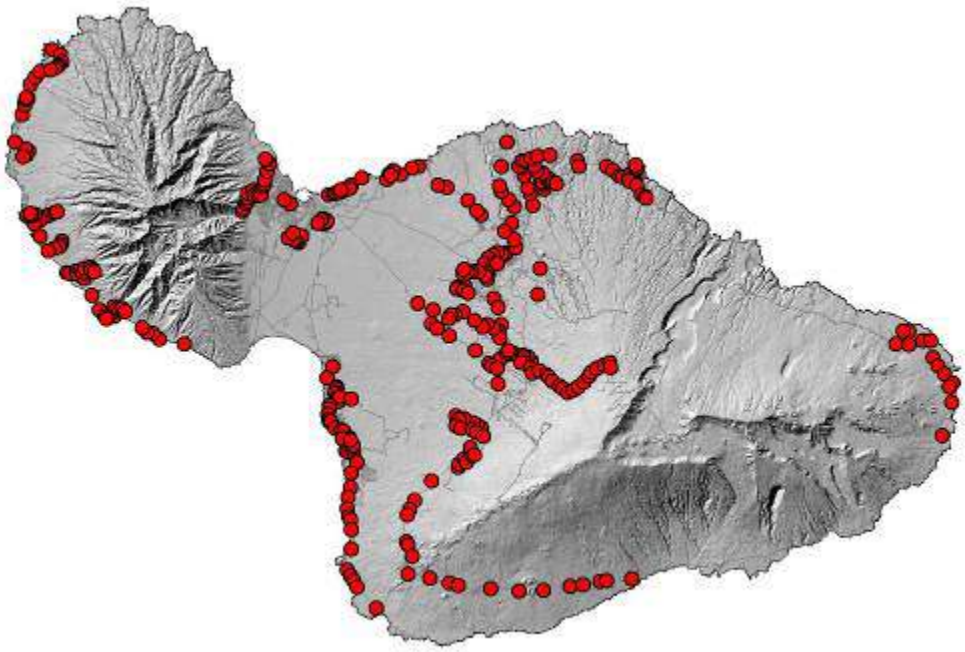

Figure 2. Map of 360 collection sites for current Maui *Wasmannia* survey.

SURVEY METHODS

Methods for this survey (Figure 2) followed protocols outlined by Conant and VanGelder (2003) which included using peanut butter baited chopsticks laid out a few meters from each other and left for about an hour, after which, ants were collected and identified.

The survey attempted to cover major portions of the island accessible by road, but focused on likely high risk areas, most notably newly landscaped areas within new developments. To locate new developments, the ArcView mapping program was used to overlay the tax map key (TMK) maps for Maui from 2000 and 2006 (Figure 3). Overlaying the two maps with different colors identified which land parcels had been subdivided recently. These new subdivisions generally install new plantings as part of the development process. It was in the vicinity of these plantings where this study focused survey efforts (Figure 4).

Additionally, other high risk areas were surveyed, including nurseries, gardens, and sites with plantings of species known to have been intercepted with LFA (*Caryota* palms, mondo grass). A few roadside transects were also done, generally representing both wet and dry climates and high and low elevations. The surveys employed distances of variable length between stations (0.25 - 1.5 miles), focusing on areas where there were good roadside pull-offs and a variety of apparently suitable habitat for LFA.

At each site, information about that site was recorded on a label, which was placed inside a vial to be used upon retrieval of the ants. Information on each label included the date, location, GPS coordinates, site number, and collectors' names. The GPS used was a Garmin eTrex unit that recorded locations and a track of the survey route to help with navigating back to collection sites.

Chopsticks covered lightly in Jif creamy peanut butter were used to test for presence of *Wasmannia* (Figure 5). It should be noted that peanut butter bait is standard for LFA surveys, but is not equally effective for all ant species. Thus other ants are likely to be under-represented in results of this survey.

Prior to use, chopsticks were cut in half and spray-painted orange on one half to make retrieval easier. At each site, about 12 peanut butter baited chopsticks were placed in areas that would likely harbor LFA, such as at the base of trees, near or in potted plants, in tree crotches, in leaf litter, near logs, planks, or bricks, near wet spots or water features (seeps, irrigation, etc.), and in cracks in concrete, such as sidewalks or walls.

Once the sticks were placed, the next site was visited and the same method repeated until an hour had passed, after which the survey team would return to the starting site and retrieve the ants from the peanut butter baited chopsticks. A standard entomological aspirator was used to collect a representative sample of ant species from the chopsticks at that site (Figure 6). Ants in the vicinity of the sticks were also collected, such as those in nearby bushes, leaf litter, under rocks, or on concrete near the bait stick. Snap cap plastic 9 dram vials with ants and labels were stored in a cooler for transport back to the lab.

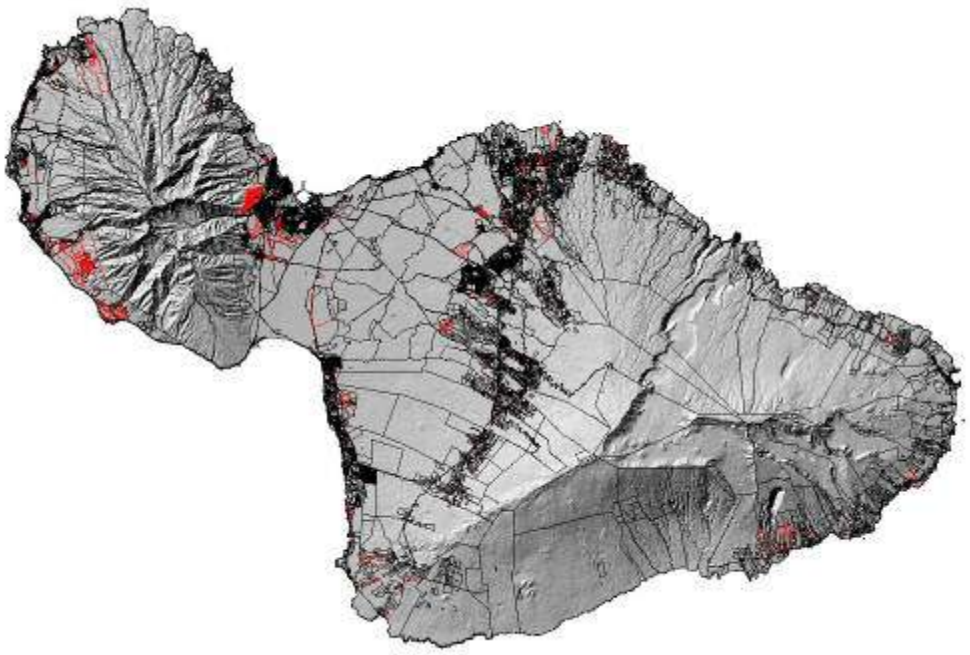

Figure 3. Subdivisions on Maui in 2000 (black lines) and new subdivisions by 2006 (red lines).

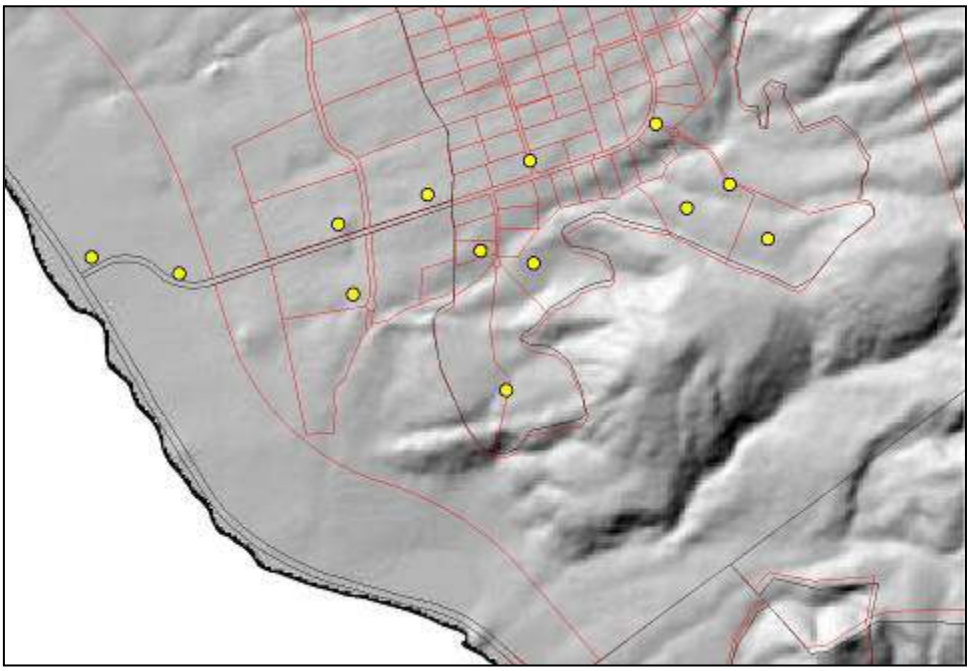

Figure 4. A typical new subdivision (red lines), and testing sites (yellow dots).

Figure 5. Ants on a peanut butter baited chopstick.

Figure 6. Collection site in newly landscaped area in new development in Kahului.

Back at the lab, ants were frozen at least overnight, then sorted and identified using a 30x power microscope (the microscope used during this survey was sufficient for identifying most ants, but could not discern very small features), placed in smaller 5 dram plastic snap cap vials with a label, and finally put back in the freezer for storage.

Data were entered (date, site number, site description, species found, GPS coordinates) into an excel spreadsheet and maps for each species were created in ArcView. At the end of the project, ants were deposited with P. Krushelnycky for archival and further analysis.

Several websites were used to help with determinations, such as AntWeb (2007) and a link tool developed by W. Haines (CTAHR 2007), as well as the current Hawaii ant key created by N. Reimer. P. Krushelnycky helped calibrate the identifications made during this study by confirming a sample of the specimens early on.

Figure 7. Map of locations used in the text.

RESULTS

About 18,000 ants were collected on 4,300 chopsticks at 360 sites. From these, 823 locations were determined for 20+ species (Table 1). A total of 23 species of ants were collected. The designation "*Cardiocondyla* spp." includes four species (*C. emeryi, C. minutior, C. venustula, and C. wroughtoni*) for which specimens were collected but we were unable to make determinations at the species level for each individual site. A detailed discussion for each species detected during the survey is found in Appendix A.

Table 1. Number of sites, frequency of detection, elevation range, and habitat type for each ant species. Identifications and nomenclature as provided by Paul Krushelnycky.

Species	# of Sites	% of Sites	Elevation (ft.)	Dry	Mesic	Wet
Anoplolepis gracilipes (F. Smith), 1857	18	5%	0-2000	x	x	x
Brachymyrmex obscurior Forel, 1893	48	13%	0-1500	x	x	--
Cardiocondyla spp.	95	26%	0-5000	x	x	x
Leptogenys falcigera Roger, 1861	4	1%	0-1500	x	x	--
Linepithema humile (Mayr), 1868	4	1%	2500-5000	--	x	--
Monomorium floricola (Jerdon), 1851	30	8%	0-2500	x	x	--
Monomorium liliuokalanii Forel, 1899	13	4%	0-1000	--	x	x
Monomorium pharaonis (Linnaeus), 1758	26	7%	0-2000	x	--	--
Ochetellus glaber (Mayr), 1862	68	19%	0-3000	x	x	--
Paratrechina bourbonica (Forel), 1886	4	1%	0-500	x	x	--
Paratrechina longicornis (Latreille), 1802	47	13%	0-2000	x	x	--
Paratrechina vaga (Forel), 1901	5	1%	0-500	x	x	x
Pheidole megacephala (Fabricius), 1793	199	55%	0-4500	x	x	x
Plagiolepis alluaudi Emery, 1894	21	6%	0-3000	x	x	--
Solenopsis geminata (Fabricius), 1804	56	16%	0-2000	x	--	--
Solenopsis papuana Emery, 1900	33	9%	0-2500	x	x	x
Tapinoma melanocephalum (Fabricius), 1793	21	6%	0-1500	x	x	--
Technomyrmex albipes (F. Smith), 1861	8	2%	0-1500	x	x	--
Tetramorium bicarinatum (Nylander), 1847	14	4%	0-1000	x	x	x
Tetramorium simillimum (F. Smith), 1851	93	26%	0-4000	x	x	--
Wasmannia auropunctata (Roger), 1863	0	0%	n/a	--	--	--
None	16	4%	0-6500	x	x	--
Total sites	**360**					
Total locations	**807**					

No individuals of *Wasmannia auropunctata* (LFA) were detected during the survey. By far the most commonly encountered ant species was *Pheidole megacephala*, found at 55% of the sites (Figure A25). *Tetramorium simillimum* was also a common ant, found at 26% of the sites (Figure A39). *Brachymyrmex obscurior* was first detected on Maui in 1997, and during this study was found to be widespread along the leeward coasts of Maui (Figure A3). Very rarely were no ants found at a site, though this did occur at a few sites (4%), especially along a stretch of Crater Rd., Kula (Figure A43).

Solenopsis geminata, the only ant known to cause stings that welt on Maui, was not detected east of Kahului or "upcountry" (Figure A29), suggesting reports of stings in areas from which this ant is not known should be promptly followed up. *Solenopsis invicta* (RIFA) was not observed during this survey. RIFA is an aggressive pest ant not known from Hawaii, but is established in areas from which Hawaii receives shipments. Because of the high-threat posed by this ant, all specimens of *S. geminata*, the closely related tropical fire ant, were inspected to be sure they were not *S. invicta*.

There is a chance that some of the ants may have been misidentified. With so many ants being looked at, even LFA may have slipped through, especially if mixed in with *Tetramorium simillimum*, or other ants similar in appearance to LFA. Attempts were made to minimize the potential for overlooking LFA by having specimens of LFA on hand to regularly re-calibrate with, and by paying extra attention when looking at species similar to LFA. All specimens from this project have been handed over to P. Krushelnycky for storage and can be further analyzed.

Detection of LFA is further complicated by its small size. Krushelnycky *et al.* (2005b) point out that, "Probably the greatest challenge in controlling this species results from its small size and inconspicuous behavior at low densities. These traits make it difficult to detect until it is already well established, and combine with the high volume of intra-state trade in ornamental plants to greatly increase the likelihood of undetected, long-distance dispersal."

Some ant species may be under-represented because of the bait chosen. Peanut butter was used in this study, since LFA is attracted to it, and detection of LFA was the primary goal of this study. Many ant species are attracted to peanut butter, but some ant species may not be attracted to peanut butter at all or may find it only slightly attractive, so that the relative abundance of ant species encountered has reduced significance. Some ant species that are known to be common on Maui were completely undetected during this survey, e.g., *Camponotus variegatus*. A list of the 12 ant species previously known from Maui (based on Nishida 2002 and Bishop Museum 2006) but not detected during this survey is given in Table 2. One of the undetected ant species, *Hypoponera opaciceps*, was collected by an earlier study in the high-elevation, subalpine zone of East Maui at 2070-2880m (6790-9450 ft) (Cole *et al.* 1992).

Table 2. Ants previously recorded from Maui, but not recorded during this survey, based on Nishida (2002) and Bishop Museum (2006).

Species
Camponotus variegatus (F. Smith), 1858
Cerapachys biroi Forel, 1907
Hypoponera opaciceps (Mayr), 1887
Hypoponera punctatissima (Roger), 1859
Hypoponera zwaluwenburgi (Wheeler), 1933
Monomorium sechhellense Emery 1894
Pheidole fervens F. Smith, 1858
Ponera swezeyi (Wheeler), 1933
Strumigenys emmae (Emery), 1890
Strumigenys godeffroyi Mayr, 1866
Strumigenys rogeri Emery, 1954
Tetramorium tonganum Mayr, 1870

DISCUSSION

Results of our survey and previous surveys suggest that LFA may not yet be present on Maui, though it could be present and undetected. Additional surveys are needed. Early effects of the expanding LFA population on the Big Island have aroused agency and public concern, reinforcing the picture emerging from the literature of the very negative effects of this invasive ant elsewhere in its expanding range. Likely effects on biodiversity, economic values (e.g., tourism industry, real estate) and local quality of life are substantial. HDOA is in the process of developing a statewide LFA strategy that will involve prevention; early detection and rapid response; containment, eradication, and control/management; research; and public outreach (HDOA 2007). This is a very positive development, but mandatory statewide public review and judicial review of rulemaking for prevention and response will require time to implement action. Maui County and the Maui Invasive Species Committee are positioned to positively assist this process and thereby assist in preparing Maui County government and the public for actions required to prevent island-wide invasion of Maui, Molokai, Lanai, and Kahoolawe by LFA. Recommendations of Wetterer and Porter (2003) for early eradication provide a good starting point:

> Incipient infestations of *W. auropunctata* should be eradicated when ever possible. Generally, an eradication attempt will require at least 4-5 treatments with an appropriate poison bait over a two year period plus extensive monitoring for several additional years. Fortunately, *W. auropunctata* is more susceptible to eradication efforts than most pest arthropods because they do not disperse by air and on the ground they usually only expand several dozen to several hundred meters per year unless they are accidentally transported in human commerce or floods. It is very important that eradication be attempted early. Based on experience in the Galápagos (Abedrabbo 1994), infestations of several hectares may be fairly easy to eradicate with persistence and several hundred to several

thousand dollars. Eradication of infestations of a few dozen hectares is probably possible, but with at least ten times the effort and ten times the funds. Based on experience with *S. invicta* in the US (Lofgren 1986), infestations of several hundred hectares will be extremely difficult to eradicate even with massive inputs of labor and hundreds of thousands of dollars. Eradication of *W. auropunctata* in larger areas is likely impossible except for the most sophisticated and well-funded eradication programs with access to millions of dollars of resources. Early detection of new infestations is probably best accomplished by educating extension agents, farmers, nurserymen, and others to recognize the ants. Equally important in many cases is to have an eradication plan in effect and pre-approved by government officials so that precious months or even years are not lost before action is taken.

CONCLUSIONS

LFA is a serious nuisance to humans and animals as well as an agricultural and ecological threat. LFA is known to disperse through human commerce and trade. LFA is established on the island of Hawaii, is known from a single infestation on the island of Kauai, and has yet to be detected on Maui.

Nurseries infested with LFA continue to ship inter-island, and while HDOA requires shipments to be tested for LFA prior to shipping, there is still the possibility that LFA could become, or already is, established on Maui.

Krushelnycky *et al.* (2005) report that USDA, ARS Florida had suggested to the Hawaii Ant Group that a quarantine at least as rigorous as the federal quarantine for *Solenopsis invicta* is what is needed to be successful to prevent further spread of LFA. A newly developed LFA strategic plan (HDOA 2007) calls for development of quarantine rules to prevent the intraisland and interisland movement of LFA, with infested and non-infested nurseries required to treat before moving or shipping. The plan also calls for development of approved quarantine treatments, since none exist.

The new LFA strategic plan (HDOA 2007) emphasizes the importance of an effective LFA detection program; detection surveys are currently being conducted by HDOA at all certified nurseries and all ports on all islands on a twice-annual basis. HDOA partnered with the Kauai Invasive Species Committee to survey all nurseries, including uncertified nurseries on Kauai that received plant material from the Big Island nurseries (Null and Gunderson 2006). Our survey focused not on nurseries but on newly developed residential sites that may have received plantings of plants from the Big Island.

We did not find LFA on Maui during this survey. However, there were many places we did not search, and LFA could have gone undetected. Maui's uncertified nurseries may be a priority for additional search. Further surveys, in connection with public awareness campaigns, will assist in detection of LFA and other ants on Maui in the future.

ACKNOWLEDGMENTS

Primary funding for the study was from the U.S. Fish and Wildlife Service. Funding was also received from the US Geological Survey, Invasive Species Program. Paul Krushelnycky, Will Haines, Neil Reimer, Pat Conant, and Mach Fukada helped with study design and ant identifications. Two anonymous reviewers provided valuable suggestions for a draft version of the text.

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APPENDIX A.

ANNOTATED CHECKLIST OF ANTS RECORDED FROM MAUI

Though we did not find LFA on Maui, in the process of looking for it, we gathered distribution information for 20+ ant species. The following section provides a map, write-up, and photos for each of the ant species found during this survey. Each map shows all survey sites and whether an ant species was present or absent at each site. The write-up for each species includes the number of sites and general location names for where it was found, a brief description of native range, worldwide distribution, impacts, previous collections on Maui from Bishop Museum's online collections database (Bishop Museum 2006), and other information. Photos for each species, generally a head and profile shot, are from AntWeb (2007), an on-line image gallery that encourages non-commercial use of their images, under an "Attribution-NonCommercial-ShareAlike" Creative Commons license. The ants are presented in alphabetical order.

Anoplolepis gracilipes -- Long legged ant

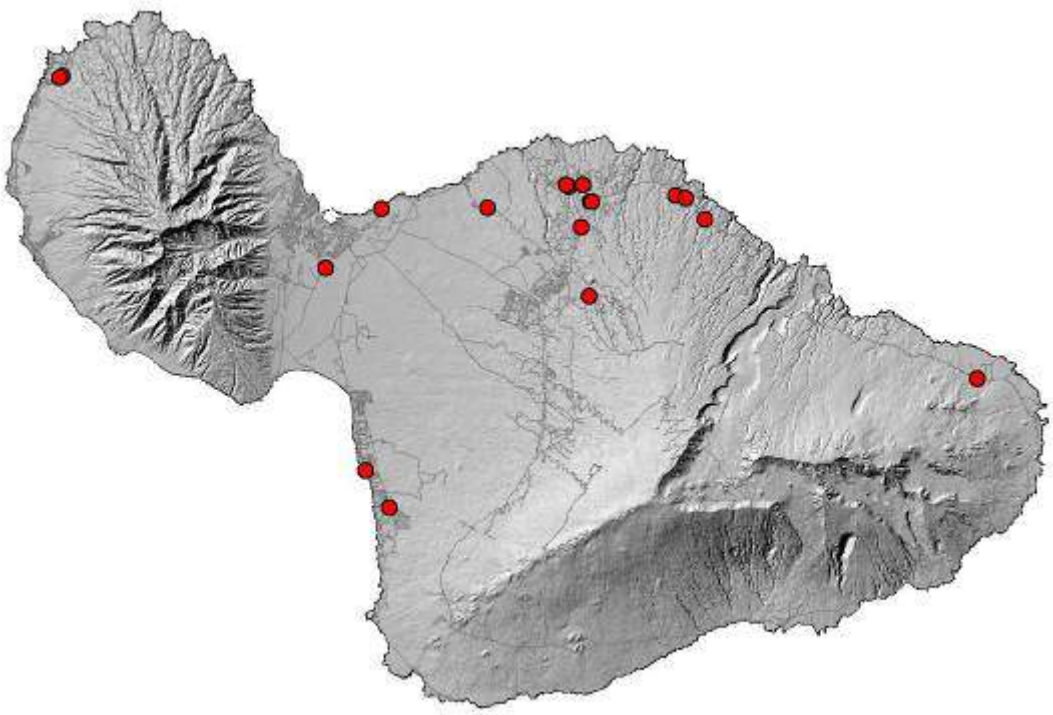

Figure A1. *Anoplolepis gracilipes* locations recorded during this survey.

Anoplolepis gracilipes was occasional in dry, mesic, and wet habitats on Maui, from sea level to 2000 ft. elevation. Found at 18 sites on Maui. The native range of *A. gracilipes* is not certain, though it is thought to have originated from Africa or Asia (Holway *et al.* 2002). *A. gracilipes* is primarily a species of the lowland, tropical rainforest, and is not commonly found in arid regions or sites above 1200 m (3937 ft) in elevation (Wetterer 2005). According to the Global Invasive Species Database (O'Dowd 2006), *A. gracilipes* is one of five ants listed among the "100 of the World's Worst Invaders." In the tropics and subtropics, *A. gracilipes* is a major environmental and a secondary agricultural pest, as well as a nuisance to humans. In the state of Hawaii, *A. gracilipes* was first documented in 1952 (Zimmerman 1953) and is now known from the islands of Kauai, Oahu, Maui, and Hawaii (Nishida 2002).

Figure A2. Head and profile images of *Anoplolepis gracilipes* by April Noble (AntWeb).

Brachymyrmex obscurior -- Brachymyrmex

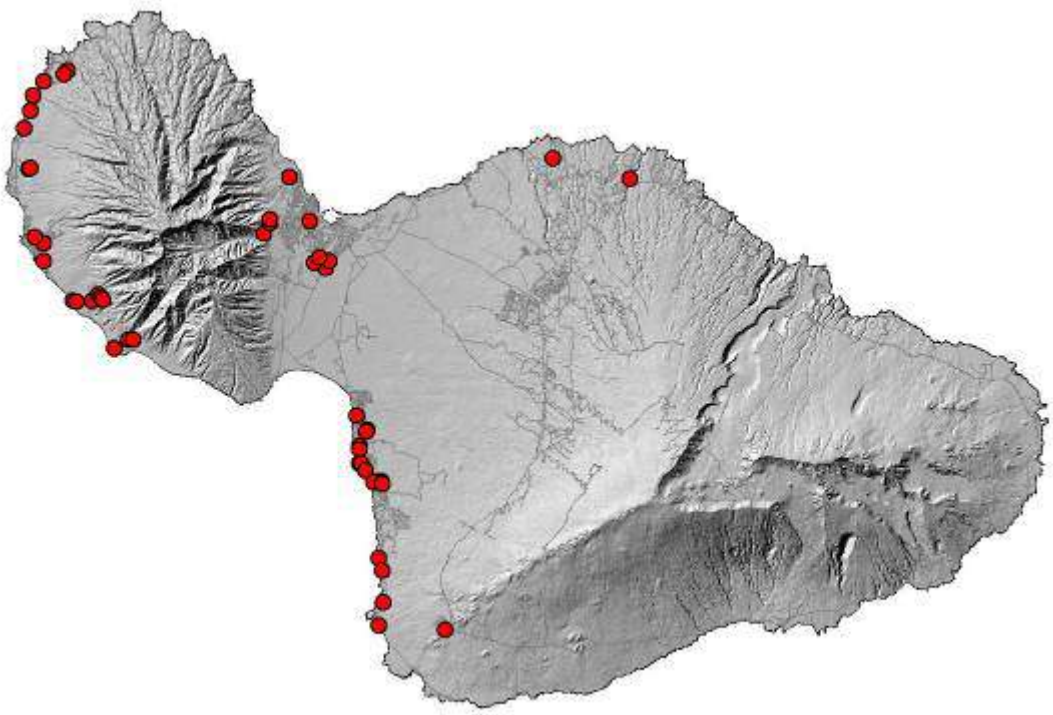

Figure A3. *Brachymyrmex obscurior* locations recorded during this survey.

Brachymyrmex obscurior was common in dry and mesic habitats on Maui, from sea level to 1500 ft. elevation. Found at 48 sites. *B. obscurior* is native from Mexico to northern South America, and many Caribbean islands (Longino 2004). It is a widespread species that is commonly found in association with disturbed human habitats (Longino 2004). In the state of Hawaii, *B. obscurior* was first documented only once in 1914 on the island of Oahu (Timberlake 1925) and was more recently documented as established on the island of Maui in 1997 (Krushelnycky *et al.* 2005b).

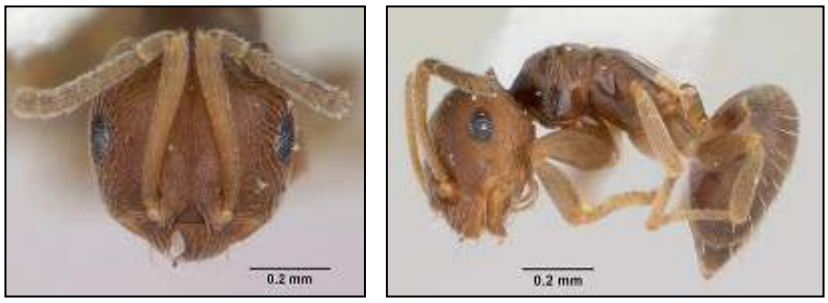

Figure A4. Head and profile images of *Brachymyrmex obscurior* by April Noble (AntWeb).

Cardiocondyla spp. -- Cardiocondyla

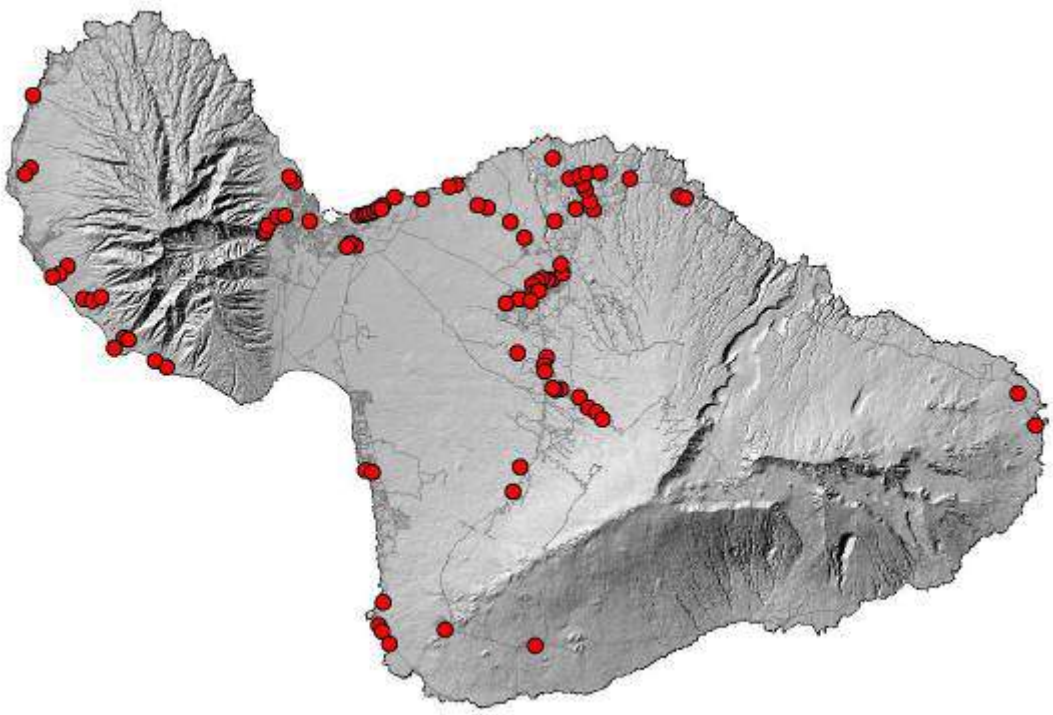

Figure A5. *Cardiocondyla* spp. locations recorded during this survey.

Cardiocondyla spp. were common in dry, mesic, and wet habitats on Maui, from sea level to 5000 ft. elevation. Found at 95 sites. This group was difficult for us to be positive that we were identifying it to species correctly. Our microscope only had 30x magnification, which made it hard to distinguish minute features between species. In addition, according to P. Krushelnycky, the group is about to be re-evaluated in Hawaii. As a result, we lumped all *Cardiocondyla* species together. Below are descriptions for the *Cardiocondyla* spp. that were confirmed by P. Krushelnycky as encountered during our surveys. The map above is lumped to genus level.

Cardiocondyla emeryi -- Cardiocondyla
C. emeryi, possibly native to Africa, is a cosmopolitan tramp species, widespread in the tropics (Seifert 2002). In the United States, it is also known from Florida and Texas (Hahn 2007). In the state of Hawaii, *C. emeryi* was first documented in 1943 (Swezey 1944) and is now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Laysan, and Pearl and Hermes Atoll (Nishida 2002, Bishop Museum 2006). Previous collections from Maui (Bishop Museum 2006) include: Kipahulu, Krauss, N. L. H., 192?, Lahaina, Swezey, O. H., 1928, Wailua, Illingworth, 1926. A few specimens of *C. emeryi* were collected by an earlier study in the high-elevation, subalpine zone of East Maui at 2070-2880m (6790-9450 ft) (Cole *et al.* 1992).

Cardiocondyla minutior -- Cardiocondyla

C. minutior is native to the Indomalayan region and is a cosmopolitan tramp species that is widespread in the tropics (Seifert 2002). In the state of Hawaii, *C. minutior* was first documented in 1893 (Seifert 2002) and is now known from the islands of Necker, Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Kure Atoll, Midway Atoll, Pearl and Hermes Atoll, Laysan, and French Frigate Shoals (Nishida 2002). In Hawaii, specimens of this species were previously called *C. nuda* in error, so all previous records of *C. nuda* are now considered *C. minutior* (Krushelnycky pers comm.).

Cardiocondyla kagutsuchi/Cardiocondyla venustula -- Cardiocondyla
Cardiocondyla venustula is native to Africa (Seifert 2003), was first documented in the state of Hawaii in 1967 (Huddleston and Fluker 1968), and was subsequently reported from the islands of Nihoa, Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Nishida 2002). However, this species is very difficult to differentiate from *Cardiocondyla kagutsuchi*, which was reported to also be present in Hawaii by Seifert (2003). Recent examination of Hawaiian specimens by specialists indicates that *C. kagutsuchi* is present on at least Hawaii, Maui, Oahu and Kauai, while *C. venustula* has so far been found only on Kauai (Krushelnycky pers. comm.). *C. venustula* (possibly actually *C. kagutsuchi*) is considered a threat to native vertebrates and invertebrates at higher elevations on Maui and Hawaii in subalpine ecosystems (Oboyski and Banko 2004).

Cardiocondyla wroughtonii -- Cardiocondyla
Native to possibly the Indomalayan region (Seifert 2003). First documented in the state of Hawaii in 1893 (Seifert 2002) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Nishida 2002). Collections known from Maui (Bishop Museum 2006) include: Iao Valley, Swezey, O. H., 1918.

Cardiocondyla emeryi

Cardiocondyla minutior

Cardiocondyla venustula

Cardiocondyla wroughtoni

Figure A6. Profile images of *Cardiocondyla* spp. by April Noble (AntWeb).

Leptogenys falcigera -- Leptogenys

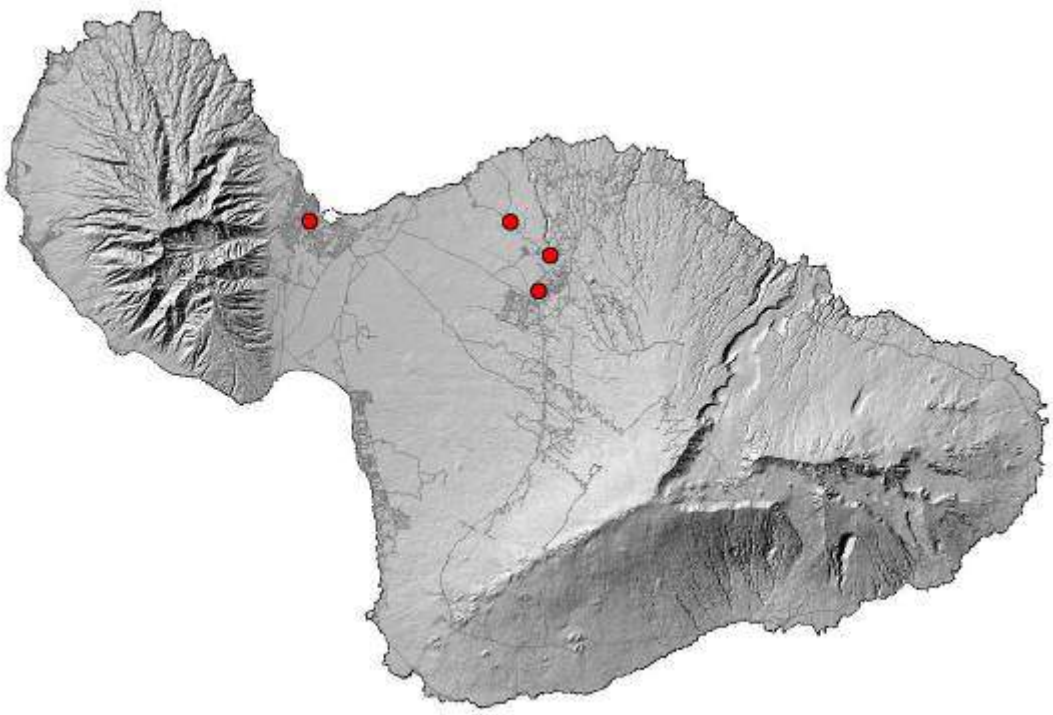

Figure A7. *Leptogenys falcigera* locations recorded during this survey.

Leptogenys falcigera was rare in dry and mesic habitats on Maui, from sea level to 1500 ft. elevation. Found at 4 sites. Native to Africa (McGlynn 1999). First documented in the state of Hawaii in 1879 (Smith 1879) and now known from the islands of Niihau, Kauai, Oahu, Molokai, Kahoolawe, Lanai, Maui, and Hawaii (Nishida 2002, Starr *et al.* 2004). Previous collections from Maui (Bishop Museum 2006) include: Olinda, Krauss, N. L. H., 1932; Wailuku, Perkins, R. C. L., 1894.

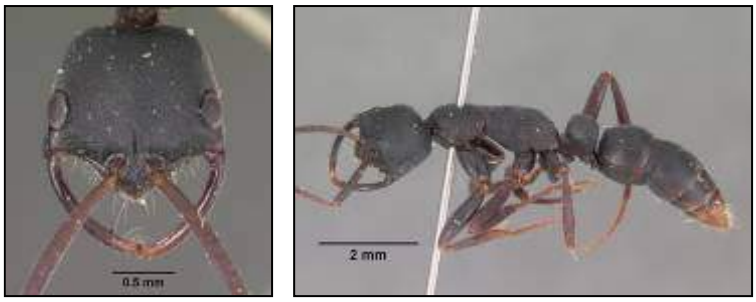

Figure A8. Head and profile images of *Leptogenys falcigera* by April Noble (AntWeb).

Linepithema humile - Argentine Ant

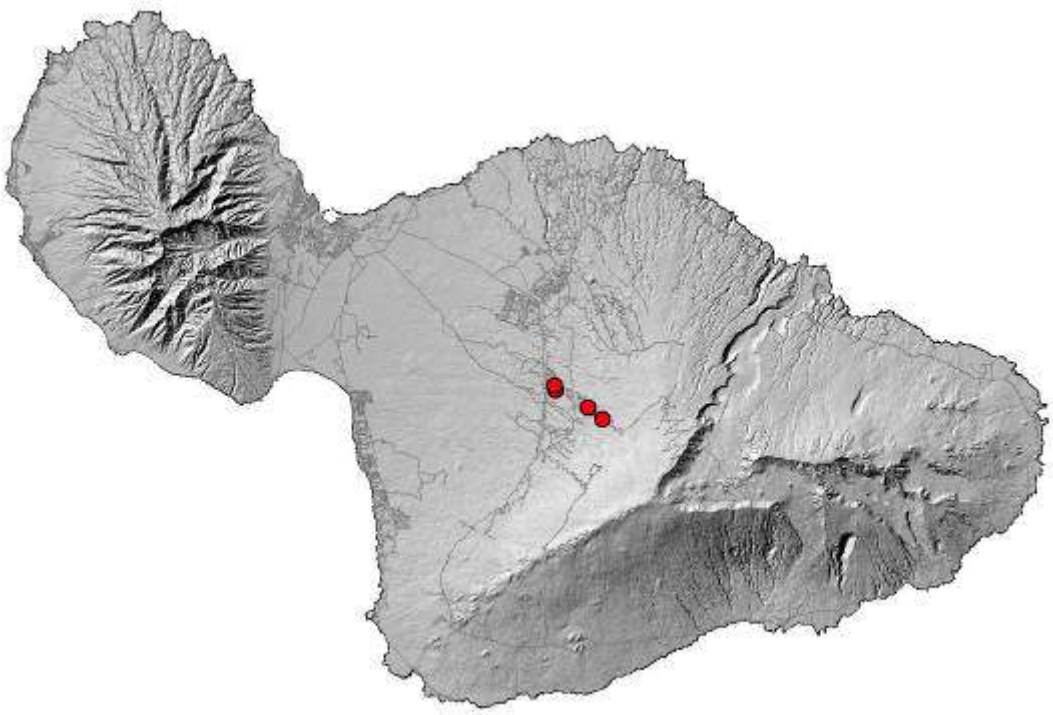

Figure A9. *Linepithema humile* locations recorded during this survey.

Linepithema humile was rare in mesic habitats on Maui, from 2500-5000 ft. elevation. Found at 4 sites. Native to mesic subtropical or mesic mild-temperate regions of northern Argentina (Tsutsui *et al*., 2001) and South America (McGlynn 1999). *L. humile* has invaded six continents and many oceanic islands (Krushelnycky 2006). The species occurs at higher elevation on Haleakala volcano than our sampling took place in this survey, at 6230-9350 ft. (1900-2850m) where it poses a direct threat within Haleakala National Park to native arthropods and an indirect threat to plants, such as the rare Haleakala silversword (*Argyroxiphium sandwicense* subsp. *macrocephalum*) (Krushelnycky *et al*. 2005a). First documented in Hawaii in 1940 (Zimmerman 1941) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: Olinda, Krauss, N. L. H., 1960.

Figure A10. Head and profile images of *Linepithema humile* by April Noble (AntWeb).

Monomorium floricola -- Bicolor trailing ant

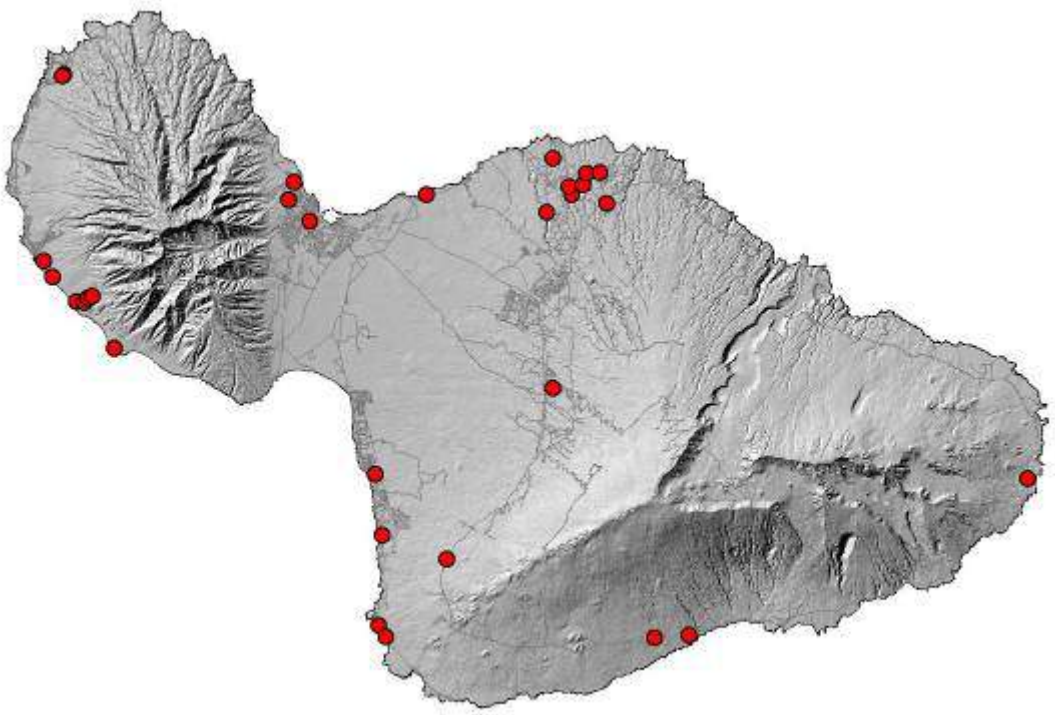

Figure A11. *Monomorium floricola* locations recorded during this survey.

Monomorium floricola was occasional in dry and mesic habitats on Maui, from sea level to 2500 ft. elevation. Found at 30 sites. Native to India and SE Asia (McGlynn 1999) and widespread in the tropics (Longino 2003a). In the state of Hawaii, first documented in 1899 (Forel 1899), and now known from the islands of Nihoa, Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Midway Atoll, Laysan, and French Frigate Shoals (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: N, M., 1894-1895.

Figure A12. Head and profile images of *Monomorium floricola* by April Noble (AntWeb).

Monomorium liliuokalanii -- Liliuokalani's ant

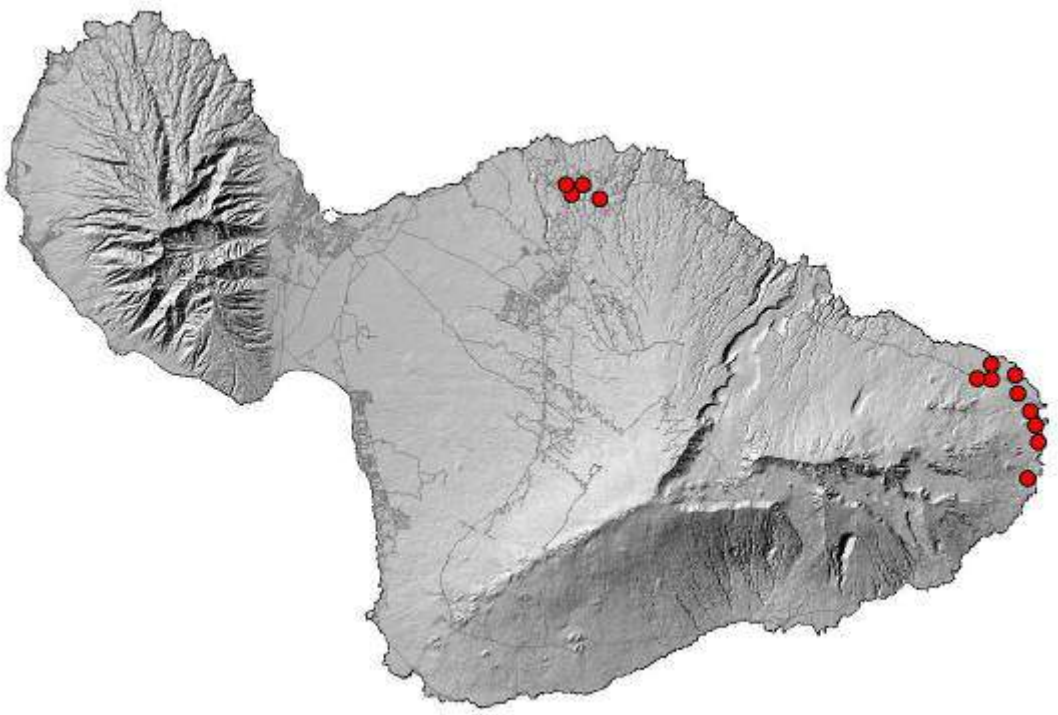

Figure A13. *Monomorium liliuokalanii* locations recorded during this survey.

Monomorium liliuokalanii was occasional in mesic and wet habitats on Maui, from sea level to 1000 ft. elevation. Found at 13 sites. Native area unknown (Krushelnycky pers. comm.). First documented in Hawaii in 1899 (Forel 1899), and now known from the islands of Necker, Kauai, Oahu, Molokai, Maui, Hawaii, Midway Atoll, and Laysan (Nishida 2002).

Figure A14. Head and profile images of *Monomorium liliuokalanii* by April Noble (AntWeb).

Monomorium pharaonis -- Pharaoh ant

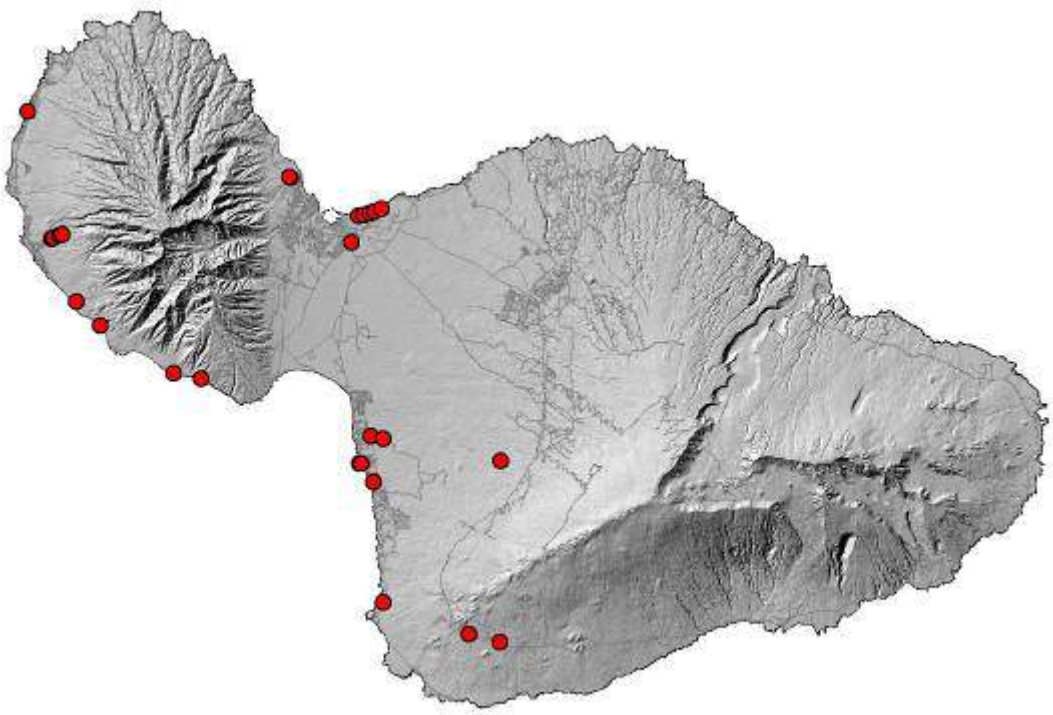

Figure A15. *Monomorium pharaonis* locations recorded during this survey.

Monomorium pharaonis was occasional in dry habitats on Maui, from sea level to 2000 ft. elevation. Found at 26 sites. Native probably to Africa (Nickerson *et al.* 2003). *M. pharaonis*, distributed throughout the world, is one of the most common household ants and is known for being difficult to control (Nickerson *et al.* 2003). First documented in Hawaii in 1913 (Gulick 1913) and now known from the islands of Kauai, Oahu, Maui, Hawaii, and French Frigate Shoals (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: Makawao Forest Reserve, Montgomery, S. L., 1979; Paia, 1909.

Figure A16. Head and profile images of *Monomorium pharaonis* by April Noble (AntWeb).

Ochetellus glaber -- Black house ant

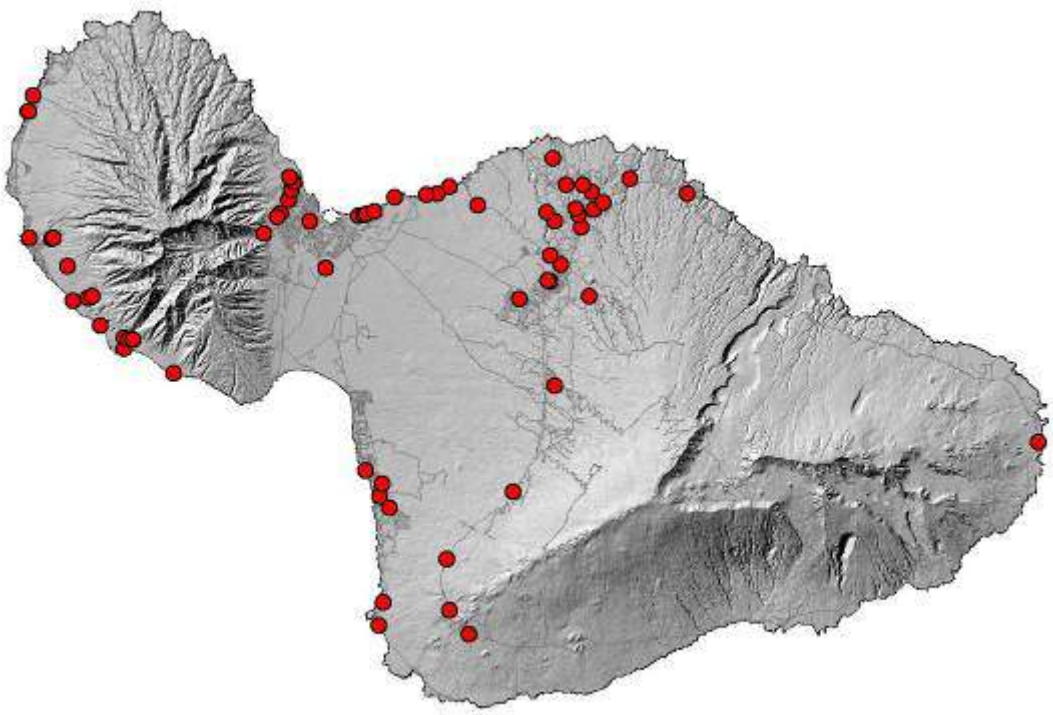

Figure A17. *Ochetellus glaber* locations recorded during this survey.

Ochetellus glaber was common in dry and mesic habitats on Maui, from sea level to 3000 ft. elevation. Found at 68 sites. Native to Australia and New Caledonia (McGlynn 1999). Introduced elsewhere in the world mostly in urban areas of Japan south through Burma and the Philippines to Australia and Fiji (Shattuck 1992), the United States (Smith 1979) and New Zealand (Brown 1958). First documented in Hawaii in 1977 (Beardsley 1980) and now known from the islands of Kauai, Oahu, Kahoolawe, Maui, and Hawaii (Nishida 2002, Starr *et al.* 2004).

Figure A18. Head and profile images of *Ochetellus glaber* by April Noble (AntWeb).

Paratrechina bourbonica -- Robust crazy ant, flesh eating ant

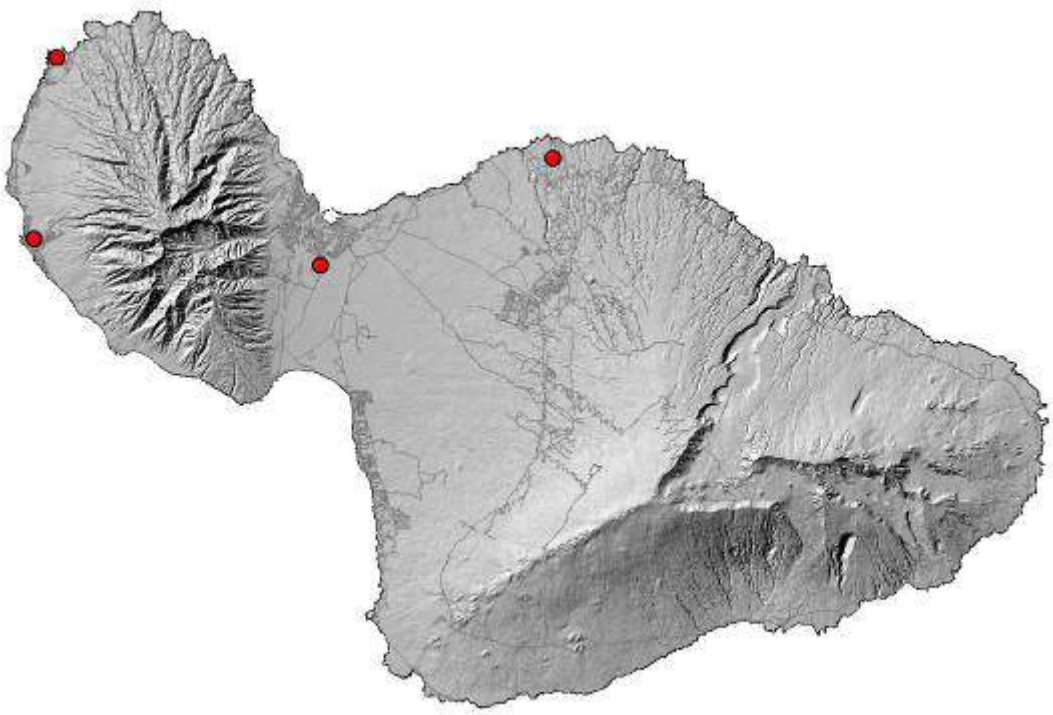

Figure A19. *Paratrechina bourbonica* locations recorded during this survey.

Paratrechina bourbonica was rare in dry and mesic habitats on Maui, from sea level to 500 ft. elevation. Found at 4 sites. Native probably from the Old World Tropics (Asia) (Wilson & Taylor 1967, Deyrup *et al.* 2000). *P. bourbonica* is a widespread tropical tramp species (Trager 1984). First documented in Hawaii in 1879 (Smith 1879) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, and Midway Atoll (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: Honomanu, Bryan, E. H., Jr., 1920; Iao Valley, Bryan, E. H., Jr., 1927; West Maui, Gressitt, J. L., 1971.

Figure A20. Head and profile images of *Paratrechina bourbonica* by April Noble (AntWeb).

Paratrechina longicornis -- Crazy ant

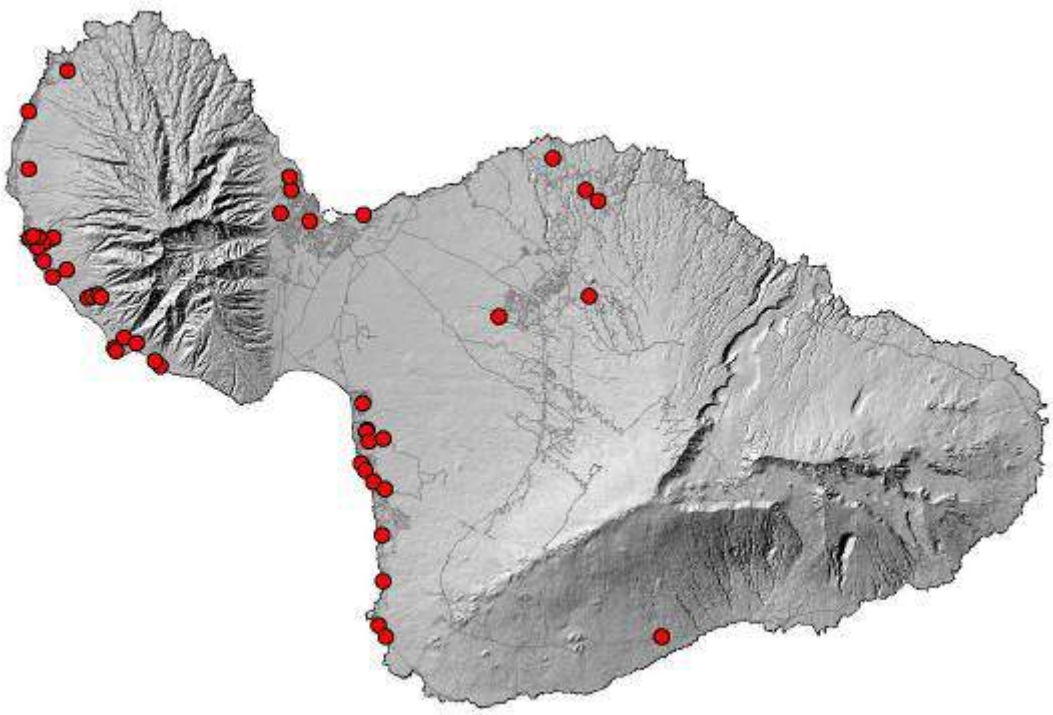

Figure A21. *Paratrechina longicornis* locations recorded during this survey.

Paratrechina longicornis was common in dry and mesic habitats on Maui, from sea level to 2000 ft. elevation. Found at 47 sites. Native to possibly Asia or Africa and found in tropical urban areas worldwide (Trager 1984). The crazy ant is named so because of its erratic and fast movements. First documented in Hawaii in 1899 (Forel 1899) and now known from the islands of Nihoa, Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, Hawaii, Midway Atoll, and French Frigate Shoals (Nishida 2002, Starr *et al.* 2004). Previous collections from Maui (Bishop Museum 2006) include: Neal, M., 1894-1895.

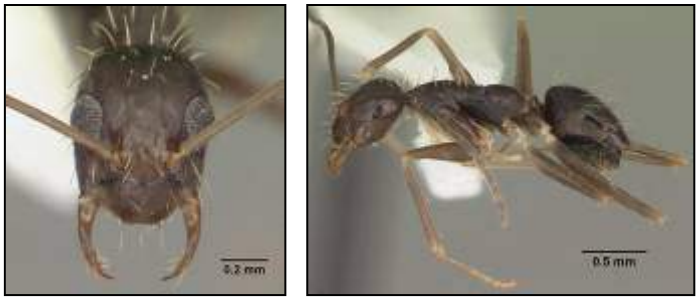

Figure A22. Head and profile images of *Paratrechina longicornis* by April Noble (AntWeb).

Paratrechina vaga -- Paratrechina

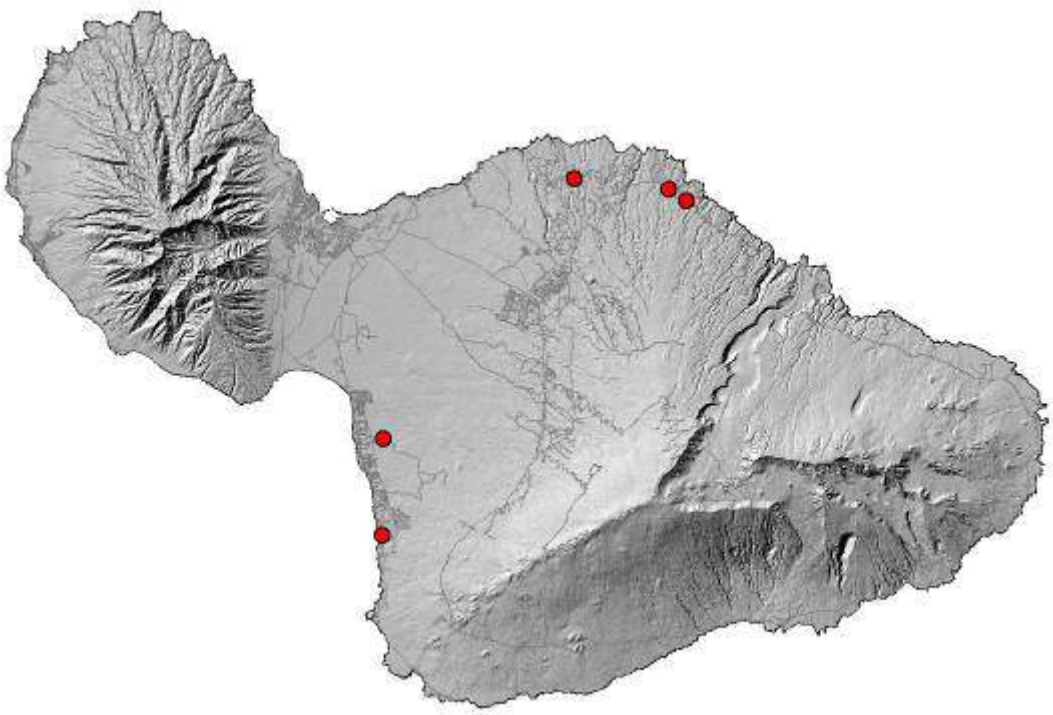

Figure A23. *Paratrechina vaga* locations recorded during this survey.

Paratrechina vaga was rare in dry, mesic, and wet habitats on Maui, from sea level to 500 ft. elevation. Found at 5 sites. Native to Australia and Southeast Asia (McGlynn 1999). This species has been introduced to many Pacific Islands. In Hawaii, it is a pest of pineapple (Carter 1967) and is mostly found in disturbed habitats in the lowlands (Reimer 1994). First documented in Hawaii in 1899 (Forel 1899) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: Keanae, Joyce, C. R., 1953.

Figure A24. Head and profile images of *Paratrechina vaga* by April Noble (AntWeb).

Pheidole megacephala -- Big headed ant

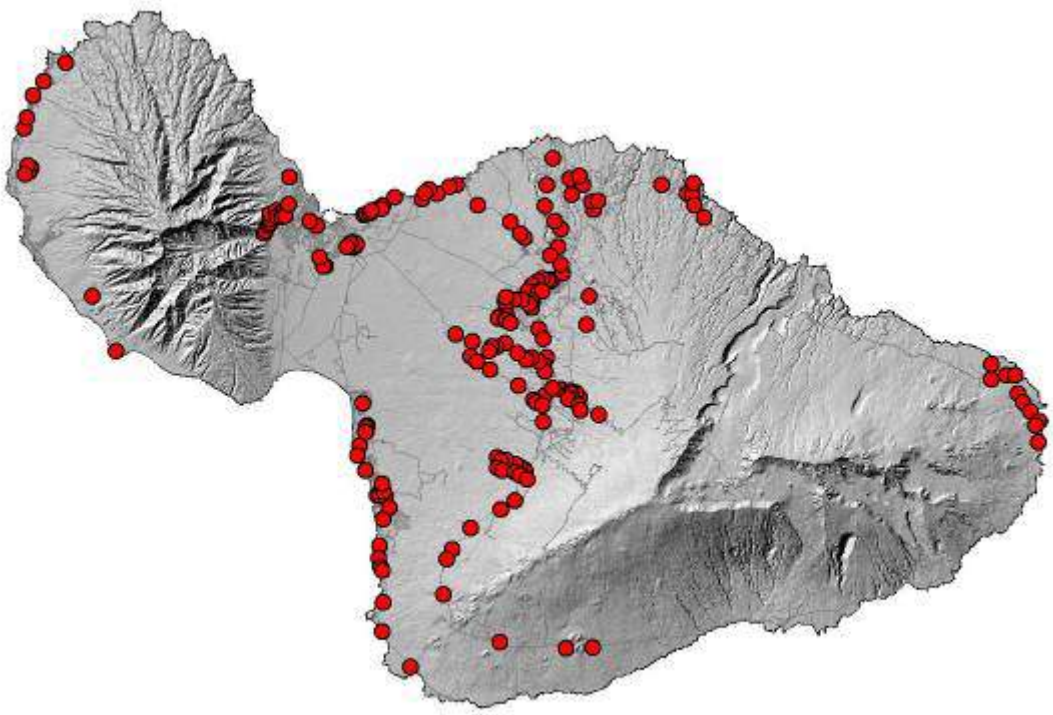

Figure A25. *Pheidole megacephala* locations recorded during this survey.

Pheidole megacephala was dominant in dry, mesic, and wet habitats on Maui, from sea level to 4500 ft. elevation. Found at 199 sites. *P. megacephala* was the most common and dominant ant found during our survey. Listed as one of the "100 world's worst pests" by the Invasive Species Specialist Group (Hoffman 2006) this well known ant is a pest worldwide in many tropical and temperate regions. First documented in Hawaii in 1879 (Smith 1879) and now known from the all the main Hawaiian Islands, Midway Atoll, Pearl and Hermes Atoll, and Laysan (Nishida 2002, Starr *et al.* 2004). Previous collections from Maui (Bishop Museum 2006) include: Iao Valley, Bryan, E. H., Jr., 1927; Yoshimoto, C. M., 1965; Kahului, Perkins, R. C. L., 1894; Kipahulu, Bryan, E. H., Jr., 1920; Maui, N, M., 1894-1895; Maui, 1915; Lahaina, near, Yoshimoto, C. M., 1965.

Figure A26. Head and profile images of *Pheidole megacephala* by April Noble (AntWeb).

Plagiolepis alluaudi -- Little yellow ant

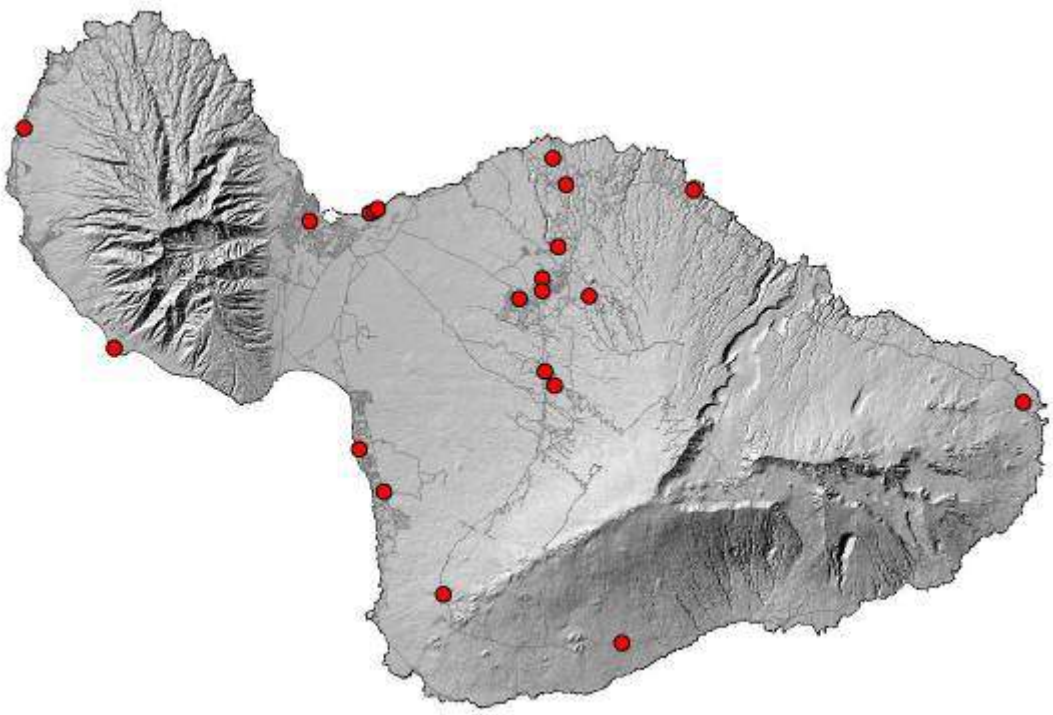

Figure A27. *Plagiolepis alluaudi* locations recorded during this survey.

Plagiolepis alluaudi was occasional in dry and mesic habitats on Maui, from sea level to 3000 ft. elevation. Found at 21 sites. Native possibly to India (McGlynn 1999). First documented in Hawaii in 1913 (Gulick 1913) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Midway Atoll, and Laysan (Nishida 2002).

Figure A28. Head and profile images of *Plagiolepis allaudi* by April Noble (AntWeb).

Solenopsis geminata -- Tropical fire ant

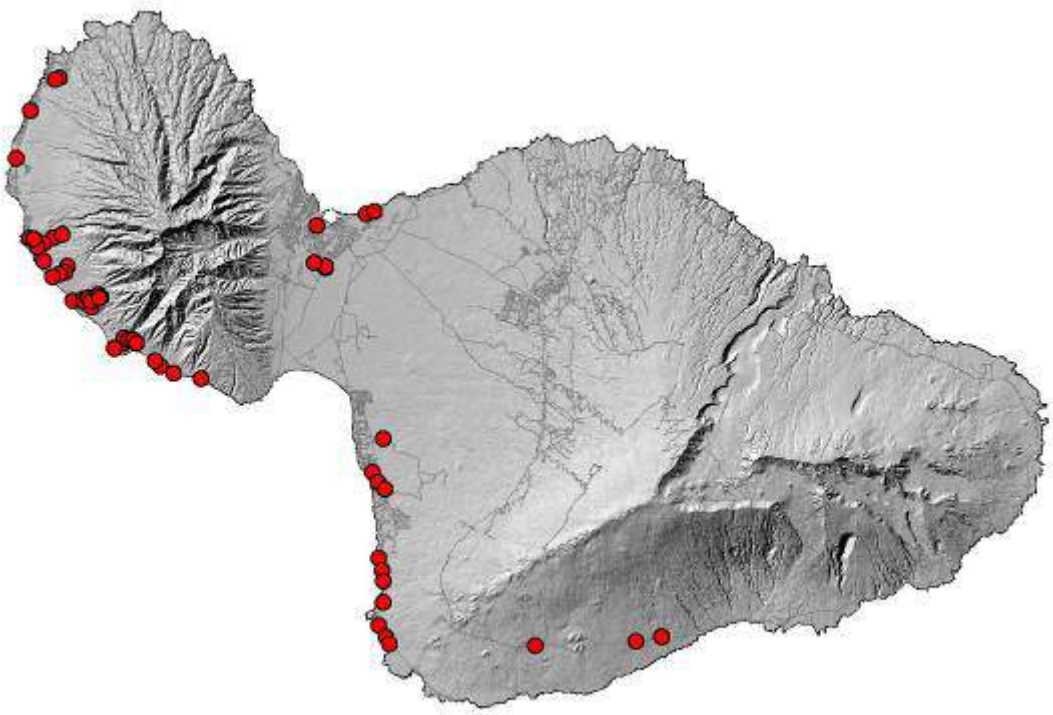

Figure A29. *Solenopsis geminata* locations recorded during this survey.

Solenopsis geminata was common to dominant in dry habitats on Maui, from sea level to 2000 ft. elevation. Found at 56 sites. All *S. geminata* were closely inspected to be sure they were not RIFA. Native to the Neotropics (McGlynn 1999), *S. geminata* has been introduced throughout the world and establishes in disturbed warm lowland sites (Yates 2006). This ant is notorious for its painful sting and rapid aggressive behavior towards any disturbance of the colony or food source Yates (2006). A single fire ant can sting multiple times causing an intense burning (fiery) sensation, followed by reddening and swelling of the skin. The sting may sometimes cause a severe, systemic allergic reaction (Yates 2006). *S. geminata* are also pests of seeds (Yates 2006). First documented in Hawaii in 1879 (Smith 1879) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, Hawaii, and Midway Atoll (Nishida 2002, Starr *et al.* 2004).

Figure A30. Head and profile images of *Solenopsis geminata* by April Noble (AntWeb).

Solenopsis papuana -- Papuan thief ant

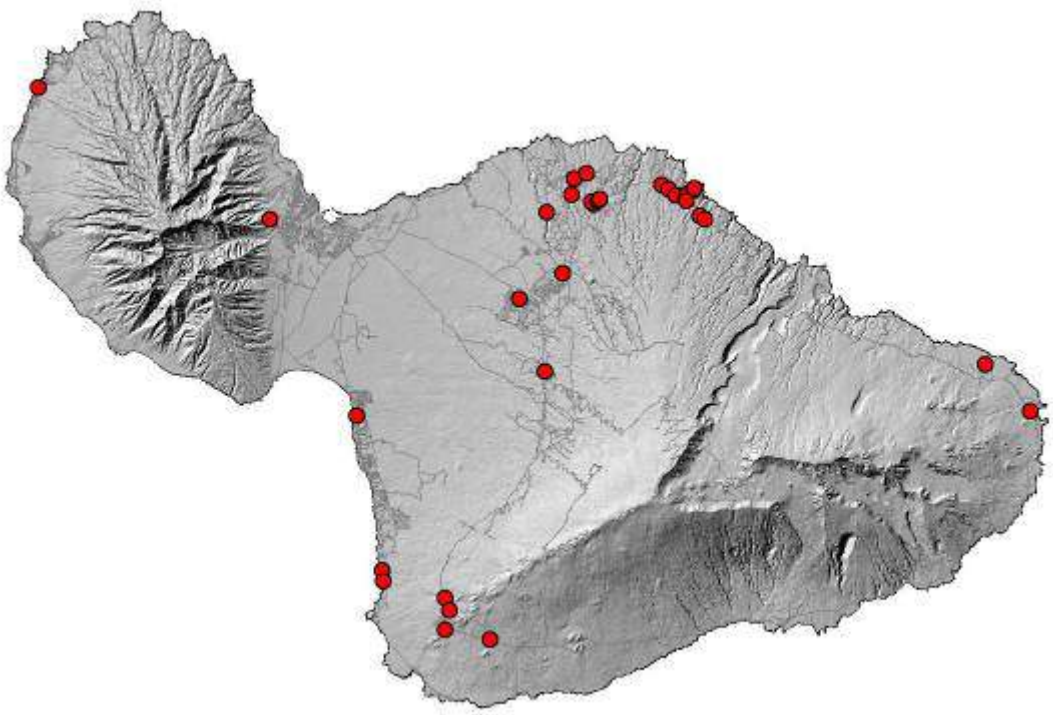

Figure A31. *Solenopsis papuana* locations recorded during this survey.

Solenopsis papuana was occasional in dry, mesic, and wet habitats on Maui, from sea level to 2500 ft. elevation. Found at 33 site. Most prevalent in moist soils. Native to the Papuanal Region (McGlynn 1999). First documented in Hawaii in 1967 (Huddleston and Fluker 1968) and now known from the islands of Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii (Nishida 2002).

Figure A32. Head and profile images of *Solenopsis papuana* by April Noble (AntWeb).

Tapinoma melanocephalum -- Ghost ant

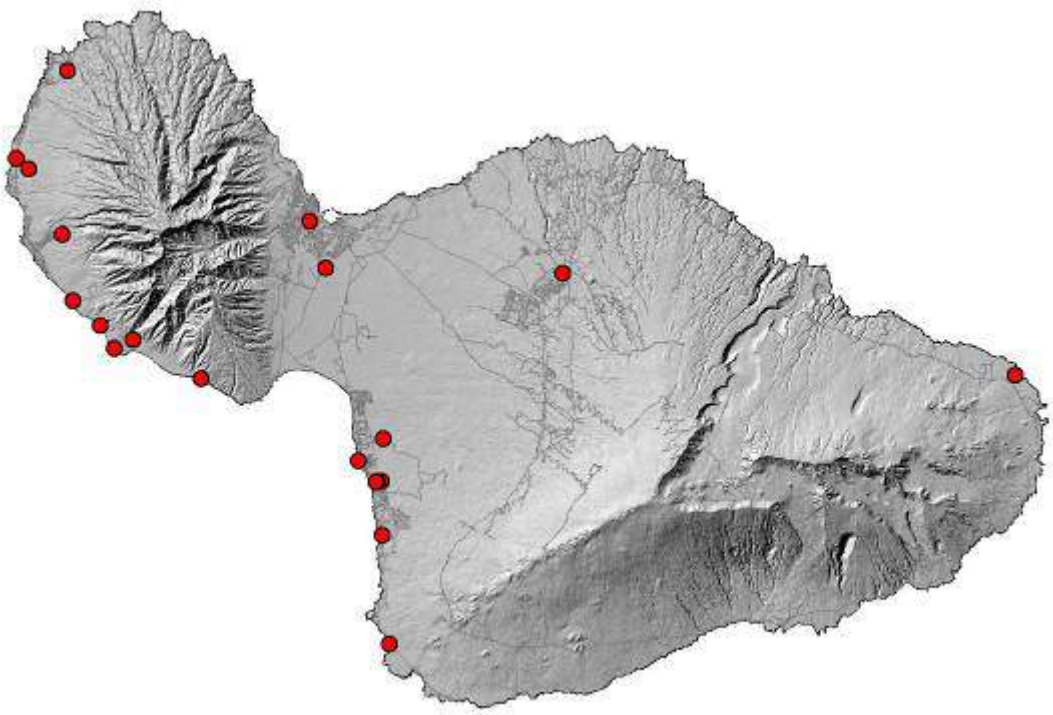

Figure A33. *Tapinoma melanocephalum* locations recorded during this survey.

Tapinoma melanocephalum was occasional in dry and mesic habitats on Maui, from sea level to 1500 ft. elevation. Found at 21 sites on Maui, mostly near houses. Native origin unknown. This tramp ant species is widespread throughout the world and is commonly associated with human habitat and is generally considered a household pest (GISD 2006). First documented in Hawaii in 1899 (Forel 1899) and now known from the islands of Nihoa, Kauai, Oahu, Molokai, Lanai, Maui, Hawaii, Kure Atoll, Midway Atoll, and Laysan (Nishida 2002).

Figure A34. Head and profile images of *Tapinoma melanocephalum* by April Noble (AntWeb).

Technomyrmex albipes -- White footed ant

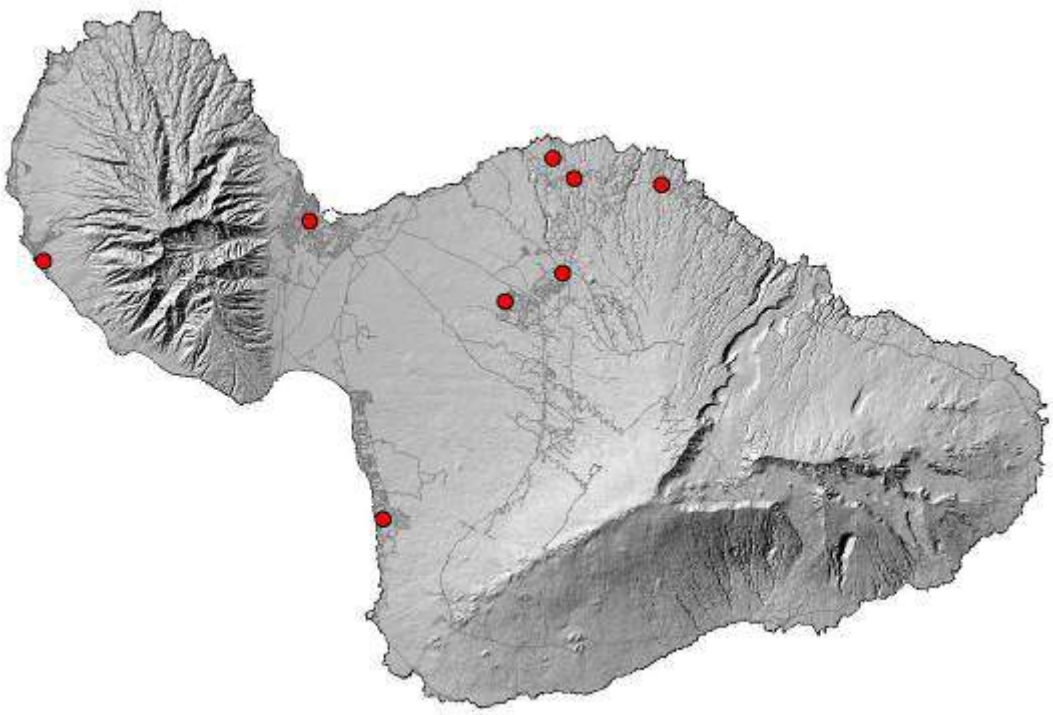

Figure A35. *Technomyrmex albipes* locations recorded during this survey.

Technomyrmex albipes was occasional in dry and mesic habitats on Maui, from sea level to 1500 ft. elevation. Found at 8 sites. Native to the Indo-Pacific area (McGlynn 1999). A pest ant in households that has been introduced to the southern United States and Hawaii, Japan, Australia, New Zealand, Africa, Polynesia, and the West Indies (Warner *et al.* 2004). First documented in Hawaii in 1911 (Swezey 1914) and now known from the islands of Kauai, Oahu, Molokai, Kahoolawe, Maui, and Hawaii (Nishida 2002, Starr *et al.* 2004). Previous collections from Maui (Bishop Museum 2006) include: Iao Valley, Bryan, E. H., Jr., 1927; Waihee, Bryan, E. H., Jr., 1919; Wailua, Isenberg, C. A., 1956.

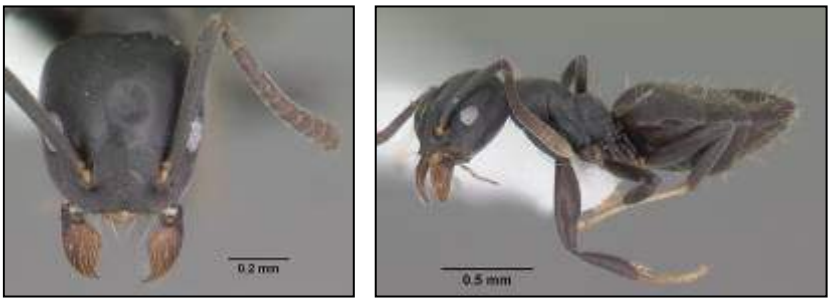

Figure A36. Head and profile images of *Technomyrmex albipes* by April Noble (AntWeb).

Tetramorium bicarinatum -- Pennant ants

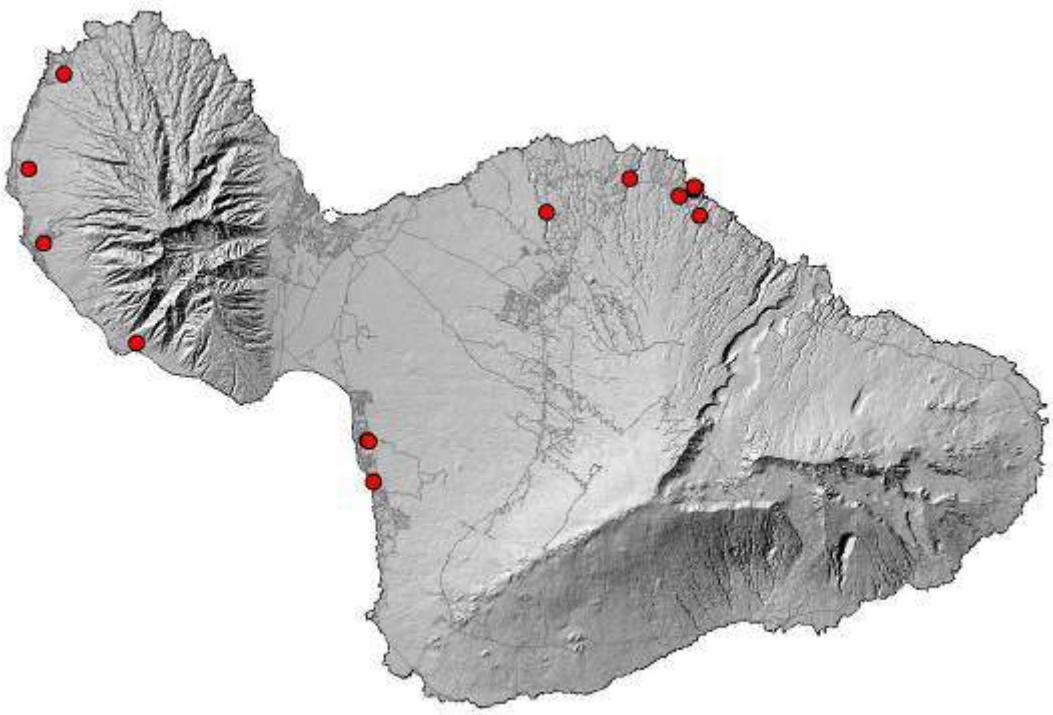

Figure A37. *Tetramorium bicarinatum* locations recorded during this survey.

Tetramorium bicarinatum was occasional in dry, mesic, and wet habitats on Maui, from sea level to 1000 ft. elevation. Found at 14 sites. A cosmopolitan tramp ant species usually found near houses (Longino 2003b). Native to southeast Asia (McGlynn 1999). First documented in Hawaii in 1879 (Smith 1879) and now found on the islands of Necker, Nihoa, Kauai, Oahu, Molokai, Maui, Hawaii, Kure Atoll, Midway Atoll, Pearl and Hermes Atoll, Laysan, and French Frigate Shoals (Nishida 2002). Previous collections from Maui (Bishop Museum 2006) include: Nahiku, Swezey, O. H., 1929.

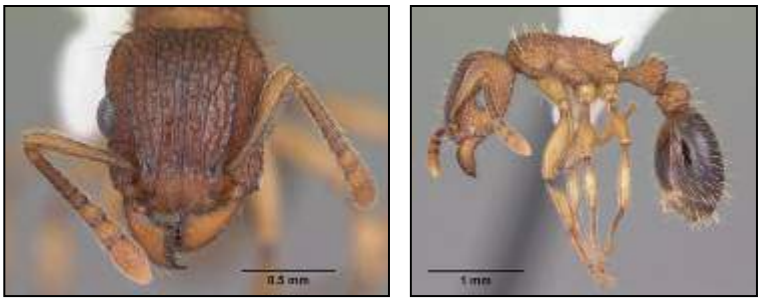

Figure A38. Head and profile images of *Tetramorium bicarinatum* by April Noble (AntWeb).

Tetramorium simillimum -- Tetramorium

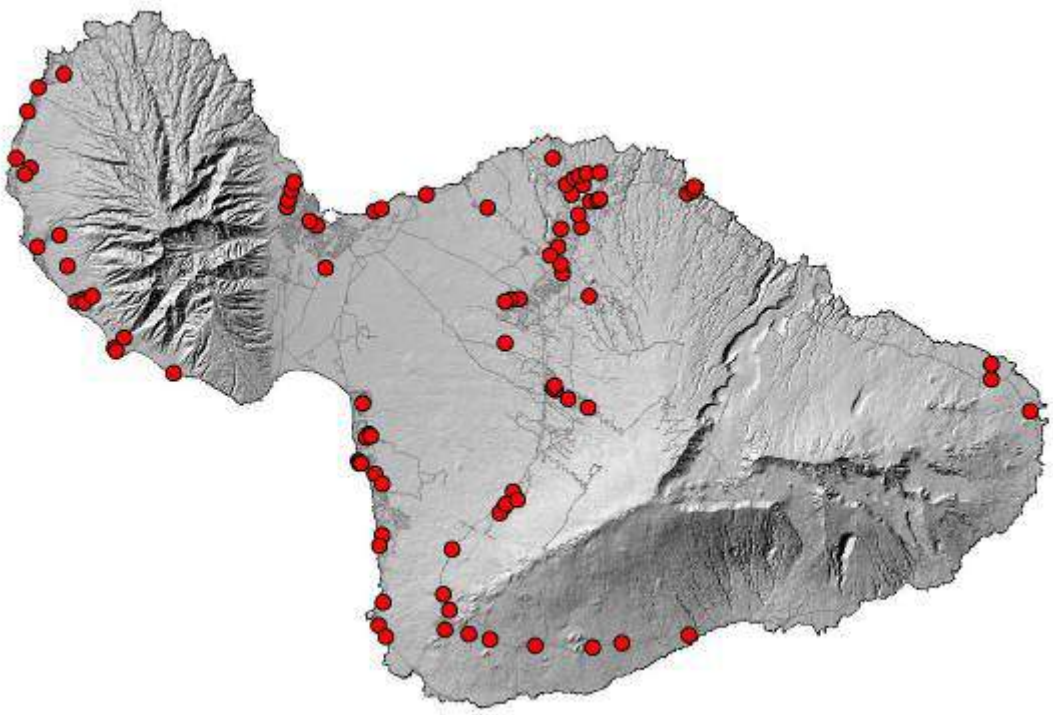

Figure A39. *Tetramorium simillimum* locations recorded during this survey.

Tetramorium simillimum was common in dry, mesic, and wet habitats on Maui, from sea level to 4000 ft. elevation. Found at 93 sites. Native to Europe (McGlynn 1999). A cosmopolitan tramp ant species that is widespread in the tropics (Longino 2003c). It is a small red ant similar in appearance to *Wasmannia auropunctata*, but *W. auropunctata* has longer setae on the face and dorsum and longer propodeal spines (Longino 2003c). First documented in Hawaii in 1934 (Wheeler 1934) and now known from the islands of Kauai, Oahu, Lanai, Kahoolawe, Maui, and Hawaii (Nishida 2002, Starr *et al.* 2004).

Figure A40. Head and profile images of *Tetramorium simillimum* by April Noble (AntWeb).

Wasmannia auropunctata -- Little Fire Ant

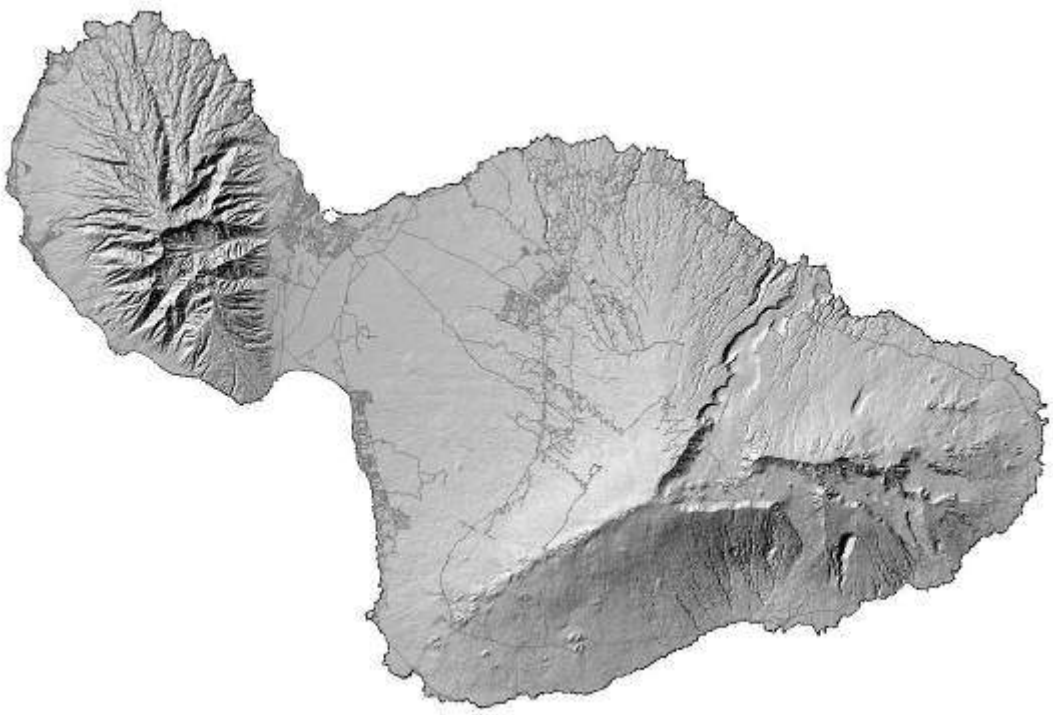

Figure A41. *Wasmannia auropunctata* locations recorded during this survey.

Not found during this survey. No locations known from Maui. Native to Central and South America (Holway *et al.* 2002). This small ant with a painful sting has hitch-hiked on shipments to many regions of the world, including the Hawaiian Islands. Common impacts of the presence of LFA include being a nuisance in agricultural settings, blinding domestic pets, and harming native wildlife. In the Hawaiian Islands, first documented in 1999 (Conant and Hirayama 2000), and now known from the islands of Hawaii and Kauai (Nishida 2002, Null and Gunderson 2006).

Figure A42. Head and profile images of *Wasmannia auropunctata* by April Noble (AntWeb).

None -- No ants found

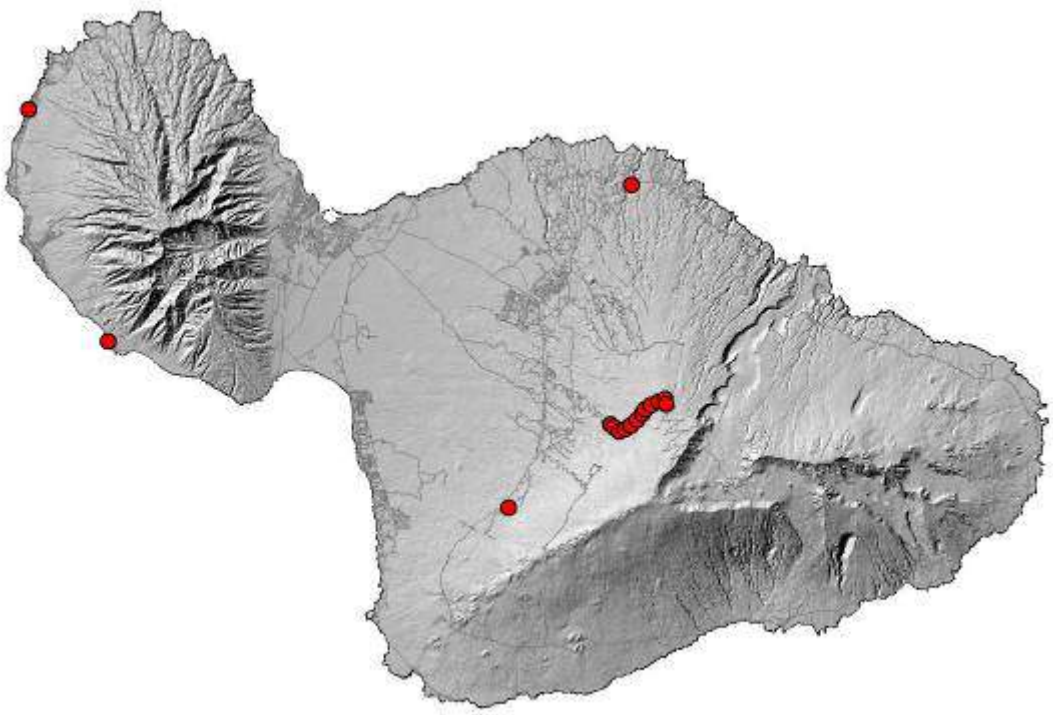

Figure A43. Locations where no ants were recorded during this survey.

Occasionally no ants were found at sites in dry and mesic habitats on Maui, from sea level to 6500 ft. elevation, especially in the 5000-6500 ft. range. There were no ants found at 16 sites on Maui, mostly in the Crater Rd. area and also at single sites in Huelo, Olowalu, Napili, and Kula.

It was not common to encounter zero ants at a station, but occasionally, this did occur. It is not certain why no ants were found at these locations. Perhaps there were ants there, and they were not detected due to the bait, or perhaps the area is an extreme habitat that supports few or no ants.