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.