Lobate Lac Scale (*Paratachardina pseudolobata* Kondo and Gullan) Invades from Oahu into Neighbor Islands: Statewide Survey in Hawaii

Zhiqiang Cheng[1*], Matthew Kellar[1], Norman Nagata[2], Bishnu Bhandari[1], and **Roshan Manandhar[1,3]**

[1]Department of Plant and Environmental Protection Sciences, College of Tropical Agriculture and Human Resources (CTAHR), University of Hawaii at Manoa, Honolulu, Hawaii. [2]Department of Tropical Plant and Soil Sciences, CTAHR, Maui Extension Office, Kahului, Hawaii. [3]Current affiliation: State of Hawaii Department of Health, Kauai Office, Lihue, Hawaii.
*Corresponding: cheng241@hawaii.edu

Abstract. In Hawaii, lobate lac scale was first detected on weeping banyan on Oahu in 2012. Since then, we have confirmed that lobate lac scale infests over 110 plant species in Hawaii, mainly ornamental and landscape plants in urban areas. The major impacts on host plants are dieback of twigs and branches, thinning of foliage, and death of the entire plant in some species. Given the frequency of interisland transportation of goods and people, it is likely that lobate lac scale spread to neighbor islands since its discovery on Oahu. We started this survey in January 2016 covering all major neighbor islands in Hawaii: Hawaii, Maui, Kauai, Molokai, and Lanai. Lobate lac scale was detected in Kona in May 2016, the first confirmed incidence of this pest on a neighbor island outside of Oahu. Lobate lac scale was detected in Lihue in January 2017, the first confirmed incidence of this pest on Kauai. With contribution from Hawaii Department of Agriculture, lobate lac scale was detected on Maui in May 2016. No lobate lac scale was detected on Molokai and Lanai in our survey. Inter-island shipping of nursery plants was considered the key route for the spread of lobate lac scale from Oahu to neighbor islands.

Key words: nursery plants, inter-island shipment, invasive species, plant quarantine

Lobate lac scale (*Paratachardina pseu-dolobata* Kondo and Gullan) (LLS) was first discovered in Florida in 1999 (Hamon and Hodges 2001), and identified as *P. lobata*. It was then determined to be a new species, *P. pseudolobata*, in 2007. In Hawaii, lobate lac scale was first detected by certified arborists on weeping banyan (*Ficus benjamina*) on Oahu in 2012 (Hawaii Department of Agriculture 2013). The native range of LLS is currently unclear, but very likely tropical Asia. This uncertainty of native range makes it difficult to identify natural biological control agents in a timely manner. Some efforts have been made in Florida but have very limited success (<1% parasitism) (Howard et al. 2010), and we also observed no natural enemies so far in our control research on and statewide survey of this pest here in Hawaii.

Mature lobate lac scales, about 2 mm long and 2 mm wide, have an x-shaped appearance and a deep maroon color (Figure 1a). The first instar measures approximately 0.4 mm in length and has a deep red color. Lobate lac scale mainly infests young woody stems of around

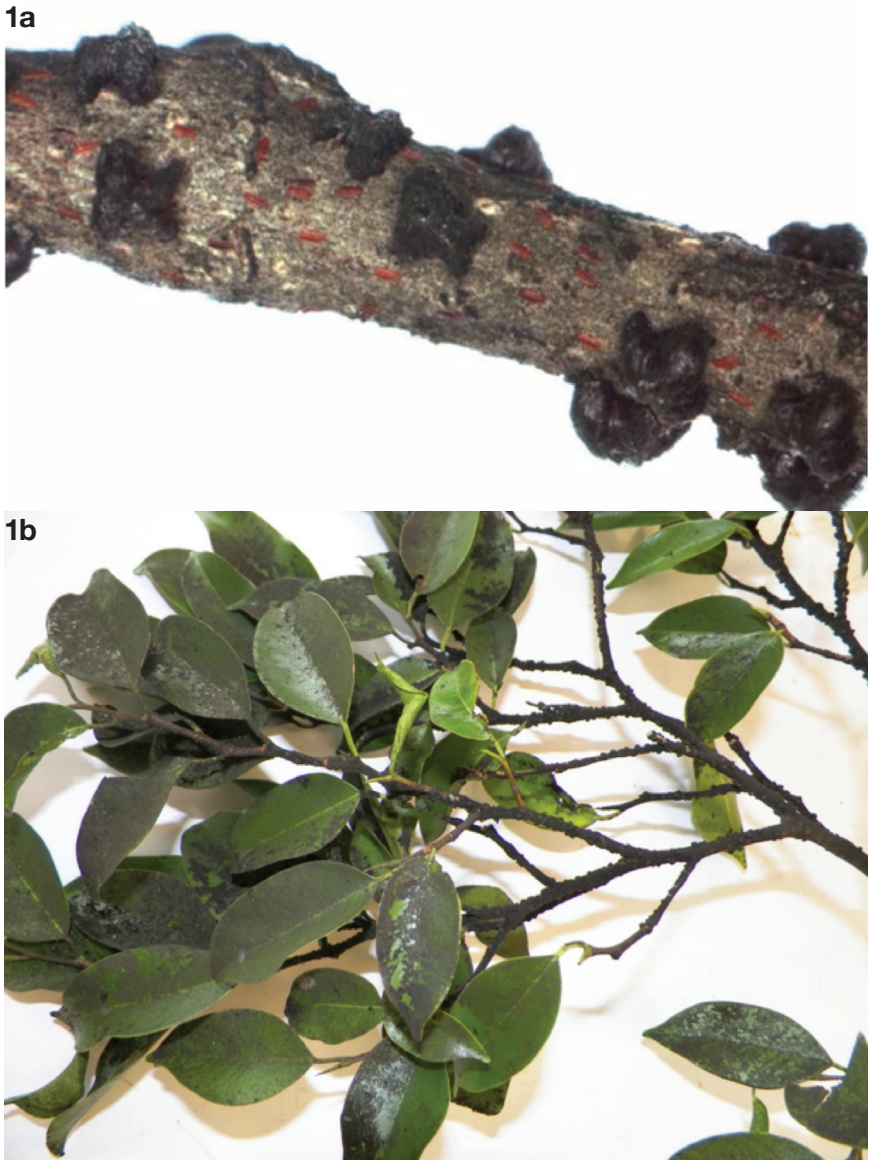


Figure 1. Mature female lobate lac scale (x-shaped, deep maroon color) and crawlers (red color) (1a); sooty mold formation on twigs and leaves (1b).

pencil size thickness. The "honeydew" secretion of this insect leads to sooty mold development on leaves and stems, significantly reducing photosynthesis and causing an unhealthy appearance in the trees (Figure 1b). The major impacts on host plants are dieback of twigs and branches, thinning of foliage, and death of the entire plant in some species. Lobate lac scale has a wide range of hosts, consisting of more than 300 host plant species belonging to more than 50 families in

Florida (Howard et al. 2010), primarily of woody dicotyledonous plants. This insect has infested over 110 native and non-native plant species on Oahu's urban landscapes (Cheng and Bhandari 2015, Bhandari and Cheng 2018), most of which are important ornamental and landscape plant species in Hawaii. *Ficus* and *Hibiscus* species are the most common hosts of LLS on Oahu.

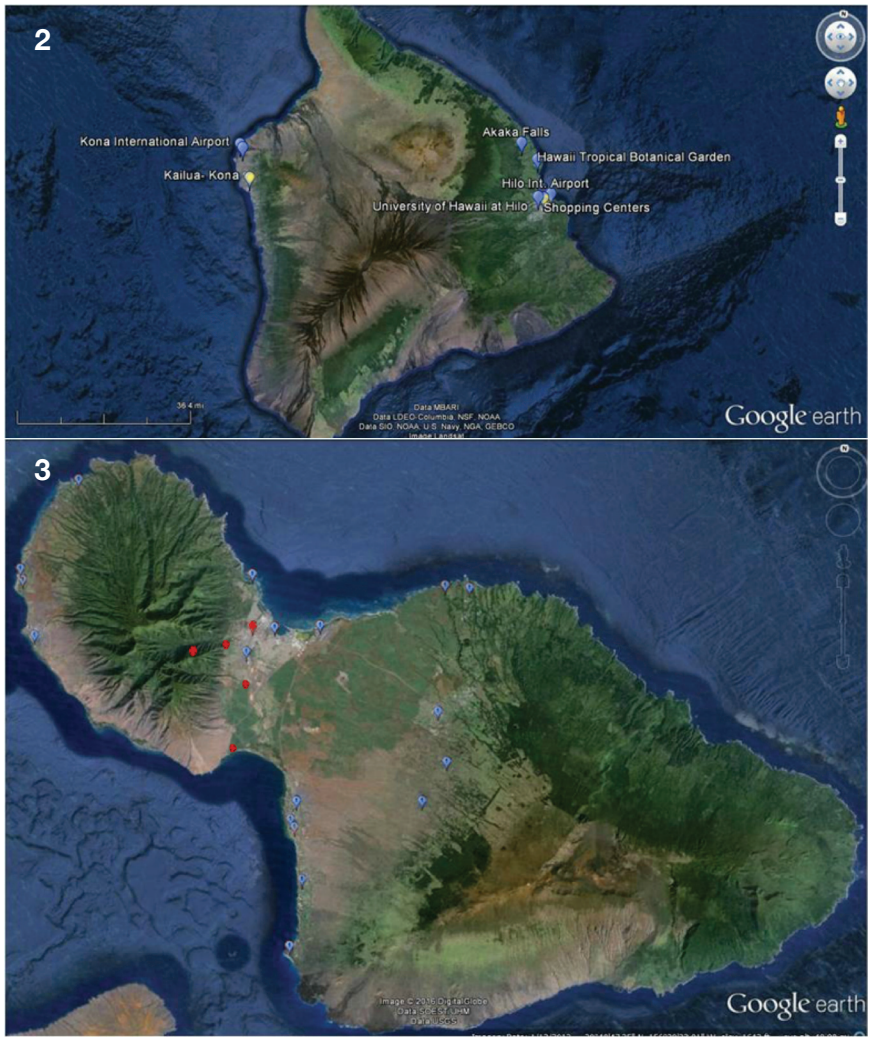
Prior to the LLS statewide survey project reported here, this pest had not been found on any neighbor island in Hawaii. However, given the frequency of interisland, Hawaii-U.S. mainland, and international transports of travelers and goods, and the fact that its population appears to be high around Honolulu's international airport, LLS is very likely to spread, and eventually disperse, to neighbor islands in Hawaii, subtropical areas in the United States, Micronesia, and other subtropical and tropical areas throughout the Pacific region.

It is a well known fact that nurseries, the landscape industry, and the "green" industries in general contribute significantly to Hawaii's tourism-driven economy. Given the fact that LLS attacks many valuable ornamental, landscape, and native plants, early detection of this invasive pest on neighbor islands in Hawaii is extremely important, both environmentally and economically. Therefore, the goal of this project was to survey LLS on major neighbor islands in Hawaii after this pest was detected on Oahu for several years since 2012. We suspected that lobate lac scale would have already had the opportunity to invade into neighbor islands when we started this statewide survey project in January 2016.

Survey Methods

Since lobate lac scale is mostly found on landscape and ornamental plants in urban areas on Oahu, in this statewide survey project we mainly focused on urban landscape areas where lobate lac scale infestation is likely to appear first and infestation is likely to be severe. These areas typically have lots of human traffic and activities, such as airport areas, city/town centers, university/college campuses, and more. We also focused on nurseries (garden centers) of big-box stores (such as Walmart, Home Depot, Lowe's, etc.) and some commercial nurseries when possible, because there are many possible host plants in these locations. In addition, efforts were made so that survey sites geographically represented each island surveyed as much as possible. During this project, Hawaii, Maui, and Kauai were each surveyed four times (twice a year), and Molokai and Lanai were each surveyed twice (once a year). If no LLS was detected in one survey, we typically included additional survey sites in the next surveys in addition to visiting survey sites previously covered. This survey project started in January 2016 and ended in July 2017.

On Hawaii, we surveyed the Kailua-Kona old-town area, Kona Airport, shopping centers in urban areas of Kona, Hilo Airport, Hawaii Tropical Botanical Garden, Liliuokalani Park, Banyan Drive, University of Hawaii at Hilo campus, and shopping centers in the urban areas of Hilo (Figure 2). On Maui, we surveyed Kahului Airport area, University of Hawaii Maui College campus, Ag Services of Maui, Hoolawa Farms, Pukalani Plant Company, Kihana Nursery, Kihei urban area, Wailea resort area, Lahaina Town area, Kaanapali resort area, Kapalua area, and Wailuku Mauka Iao Valley area (Figure 3). On Kauai, we surveyed National Tropical Botanical Garden, University of Hawaii Kauai Community College campus, Lihue Airport, shopping centers, and surrounding urban landscapes in Lihue (Figure 4). On Molokai, we surveyed the Molokai airport area, Palaau State Park area,



Figures 2–5. Lobate lac scale (LLS) sites surveyed. (2) Hawaii. LLS in Hilo was detected by HDOA staff (personal communication, 2017). (3) Maui. (4) Kauai. (5a) Molokai. (5b) Lanai. Color code for survey sites in Figures 2–5: Blue: no LLS detected. Yellow: LLS detected, but no longer detected in later surveys. Red: LLS detected and established.

Hoolehua area, Kaunakakai town center area, Ualapue area, Maunaloa town area, Kepuhi Beach Resort, Papohaku Beach Park, and Wavecrest Resort (Figure 5a). On Lanai, we surveyed Lanai Airport, Kaumalapau barge harbor, the Four Seasons Resort at Manele, Lanai City center area, Four Seasons Resort at Koele, and Halulu Gulch (Figure 5b).

Visual inspection is the only valid survey method for LLS (Molet and Jackson 2015). At each survey site, landscape and


4
Kapaa Beach Park
Shopping Centers
Wailua Falls
Lihue Airport
Shopping Centers
Kauai Community College
National Tropical Botanical Garden
Google earth


5a
Google earth


5b
Halulu Gulch
Four Seasons at Koele
Lanai City
Kaumalapa'u Barge Harbor
Lanai Airport
Four Seasons at Manele

ornamental plants (including landscape trees, shrubs, ornamentals, and other woody vegetation) were inspected for LLS. At least five individual plants per species, whenever possible, were examined at each survey site. A minimum of five branches/twigs per plant were inspected, whenever possible. In case of plant species that are infested by LLS but cannot be identified on site, in addition to plant pictures recorded, plant samples were collected for consultation with appropriate experts at the University of Hawaii at Manoa.

In our survey, a plant species was considered as a host of LLS if at least one living mature female was found on the plant (Howard et al. 2006). In reality, we always observed multiple adults and sometimes also crawlers on the host plants identified in our survey.

Results and Discussion

Hawaii island. We focused on Hilo and Kona urban areas when surveying Hawaii island. Surveys were conducted on January 19, 2016 (Kona area), January 25, 2016 (Hilo area), May 04 to 05, 2016 (Hilo and Kona areas), February 27 to March 01, 2017 (Hilo and Kona areas), and July 25 to 27, 2017 (Hilo and Kona areas). We did not detect LLS in January 2016. However, we detected LLS in the nursery center of a major big-box store in Kona on May 05, 2016. The infested plants were potted juniper (*Juniperus* sp.). This was also a new host identified in Hawaii, in addition to the ones we reported previously (Cheng and Bhandari 2015, Bhandari and Cheng 2018). These potted plants were shipped to Kona from a plant nursery on Oahu, where LLS is widely spread. This was the first confirmed LLS incidence on a neighbor island outside of Oahu. The first author informed the Hawaii Department of Agriculture (HDOA) immediately. HDOA seized those infested plants, and stepped up surveillance for LLS. HDOA staff on Hawaii then spent considerable time surveying for LLS and confirmed its presence in the nursery center of a major big-box store in Hilo (personal communication, 2017). However, LLS was no longer detected in the nursery center of those major big-box stores and surrounding areas in Kona and Hilo during our latest surveys in 2017.

Maui. Surveys on Maui were conducted on January 13, 2016, March 29 to 30, 2016, December 06 to 07, 2016, and February 15 to 16, 2017. We did not detect LLS in our January and March 2016 surveys. After we detected LLS in Kona on May 05, 2016, and notified HDOA this incidence, HDOA stepped up its surveillance for LLS. HDOA staff on Maui, Mr. Mach Fukada, spent considerable time to survey this pest on Maui soon after, and confirmed a light LLS infestation in Iao Valley area in the week of May 15, 2016 (personal communication, 2016). Affected plants there were *Hibiscus* spp., *Dodonaea* spp., and *Syzygium cumini*. In our third survey on December 6–7, 2016, we re-affirmed LLS in the Iao Valley area as reported by HDOA. The LLS infestation level in Iao Valley area ranged from low to high based on the infestation scale described by Pemberton (2003). In our last survey on Maui on February 15–16, 2017, we found an additional host plant of lobate lac scale, ohia, which has been reported as a LLS host on Oahu (Kaufman and Higashi 2015). We also detected LLS on *Hibiscus* spp. at four new locations outside of the Iao Valley area: Wailuku Town Center, New Wailuku Heights, Waikapu area, and Maalaea Bay area. Lobate lac scale infestation in these new areas was lower than that in the Iao Valley area.

Kauai. Surveys on Kauai were conducted on January 21, 2016, May 10, 2016, January 24, 2017, and June 29, 2017. We did not detect LLS in our 2016 surveys.

However, we detected LLS in the nursery center of a major big-box store in Lihue on January 24, 2017. The infested plants were potted wax ficus (*Ficus microcarpa* var. *crassifolia*) and potted dwarf bottlebrush (*Callistemon citrinus*). Dwarf bottlebrush was also a new host identified in Hawaii in addition to the ones we reported previously (Cheng and Bhandari 2015, Bhandari and Cheng 2018). These potted plants were shipped to Lihue from a plant nursery on Oahu. This was the first confirmed LLS incidence on Kauai. The first author informed HDOA immediately, and HDOA seized those infested plants. However, LLS was no longer detected in the nursery center of that major big-box store and surrounding areas in Lihue during our latest survey in June 2017.

Molokai and Lanai. We surveyed Molokai on April 28, 2016 and October 25, 2016, and Lanai on July 6, 2016 and November 1, 2016. No LLS was detected on either Molokai or Lanai.

The first detections of LLS on Hawaii (May 2016) and Kauai (January 2017) in our statewide survey are alarming yet not surprising. Considering the frequency of transportations of people and goods between Hawaiian Islands, there is a good chance that LLS already spread to neighbor islands after its first confirmation on Oahu in 2012. In both Kona and Lihue, we detected LLS in the nursery center of major big-box stores. Similarly, HDOA staff detected LLS in the nursery center of a major big-box store in Hilo (personal communication, 2017). Further investigation indicated that infested plants in these stores were shipped from plant nurseries on Oahu. This reaffirms the common pathway of ornamental/landscape pests between Hawaiian Islands and underscores the importance of plant/pest quarantine not only between Hawaii and other states and regions but also within the state. Although LLS on Maui was first found in open environment, it is noteworthy to point out that the initial LLS infestation was found on ornamental/landscape plants in a relatively newly developed residential area. It is possible that LLS there came with those ornamental/landscape plants from stores whose suppliers are plant nurseries on Oahu.

Management of lobate lac scale has not been extensively studied. Since there is no biological control agent readily available, the few studies on LLS management have focused on chemical controls. Research conducted at University of Florida showed that the systemic insecticide imidacloprid was effective to some extent in controlling LLS on Chinese banyan (*Ficus microcarpa*) when applied via soil drenching (Howard and Steinberg 2005). Bhandari and Cheng (2018) tested two systemic insecticides, imidacloprid and emmamectin benzoate, delivered via trunk injection, against LLS on weeping banyan (*Ficus benjamina*) and Chinese banyan (*Ficus microcarpa*). They concluded that imidacloprid via trunk injection was very effective against LLS, both curatively and preventively, on those *Ficus* species, and the protection lasted at least two years after one single injection treatment (Bhandari and Cheng 2018).

The fact that we did not detect LLS any more in the nursery centers of those major big-box stores on Hawaii and Kauai and open environment on these two islands indicates that LLS is possibly eradicated from those localized incidences on these two islands after HDOA received our warning and stepped up its surveillance for LLS statewide. However, LLS has already spread to multiple locations on Maui and thus needs to be managed there following appropriate management recommendations (Howard and Steinberg 2005, Bhandari and Cheng 2018).

Acknowledgments

This project was partially funded by the USDA NIFA Hatch project HA-9033H managed by CTAHR, and Maui County Office of Economic Development. We thank plant nurseries that participated in this survey. We also thank Mr. Mach Fukada and Mr. Stacey Chun (HDOA staff on Maui and Hawaii, respectively) for personal communications regarding lobate lac scale on their respective islands. We also thank anonymous reviewers whose suggestions greatly improved this manuscript.

Literature Cited

Bhandari, B.P., and **Z. Cheng.** 2018. Lobate lac scale, *Paratachardina pseudolobata* (Hemiptera: Keriidae), in Hawaii's urban landscape: hosts and management. International J. Tropical Insect Sci. 38(1): 71–76.

Cheng, Z., and **B.P. Bhandari.** 2015. Biology, management, and updated host range of the lobate lac scale (*Paratachardina pseudolobata*) in Hawai'i's urban landscapes. CTAHR, University of Hawaii at Manoa. www.ctahr.hawaii.edu/oc/freepubs/pdf/IP-34.pdf (accessed March 08, 2018).

Hamon, A.B., and **G. Hodges.** 2001. Pest alert: Lobate lac scale, *Paratachardina pseudolobata* Kondo & Gullan (Hemiptera: Kerriidae). Florida Department of Agriculture and Consumer Services, Division of Plant Industry. http://www.freshfromflorida.com/content/download/68152/1612623/Pest_Alert_-_Paratachardina_pseudolobata,_Lobate_lac_scale.pdf (accessed March 08, 2018).

Hawaii Department of Agriculture. 2013. Lobate lac scale *Paratachardina pseudolobata* Kondo and Gullan (Hemiptera: Kerriidae). New Pest Advisory, January 2013, No. 12-03. https://hdoa.hawaii.gov/pi/files/2013/01/3-27-2013-Lobate-lac-scale-NPA.pdf (accessed March 08, 2018)

Howard, F.W., R.W. Pemberton, G.S. Hodges, B. Steinberg, D. McLean, and **H. Liu.** 2006. Host plant range of lobate lac scale, *Paratachardina lobata*, in Florida. Proc. Fl. State Hort. Soc. 119: 398–408.

Howard, F.W., R.W. Pemberton, S. Shroer, and **G. Hodges.** 2010. *Paratachardina pseudolobata* (Coccoidea: Kerriidae): Bionomics in Florida. Fl. Entomol. 93: 1–7.

Howard, F.W., and **B. Steinberg.** 2005. Root drenches and topical insecticide treatments for control of the lobate lac scale, *Paratachardina lobata* (Chamberlin). Proc. Fl. State Hort. Soc. 118: 314–318.

Kaufman, L.V., and **C.H.V. Higashi.** 2015. Expansion of lobate lac scale distribution into Oahu forest systems. Proc. Hawaiian Entomol. Soc. 47: 83–92.

Molet, T., and **L.D. Jackson.** 2015. CPHST Pest Datasheet for *Paratachardina pseudolobata*. USDA-APHIS-PPQ-CPHST. https://caps.ceris.purdue.edu/webfm_send/2832 (accessed March 08, 2018).

Pemberton, R.W. 2003. Invasion of *Paratachardina lobata lobata* (Hemiptera: Kerriidae) in South Florida: A snapshot sample of an infestation in a residential yard. Fl. Entomol. 86(3): 373–377.