








First record of two invasive species of *Crypticeria* (Hemiptera: Monophlebidae) causing outbreaks in urban green areas of Guayas Province, Ecuador

Primer registro de dos especies invasoras de *Crypticeria* (Hemiptera: Monophlebidae) causantes de brotes poblacionales en áreas verdes urbanas de la provincia de Guayas, Ecuador

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Abstract: The scale insect genus *Crypticeria* Cockerell, 1895 (Hemiptera: Coccothraupidae: Monophlebidae: Iceryini) is mainly distributed in the New World and includes numerous pest species despite being a relatively small group. Ovisacs have longitudinal flutes or grooves in those species that produce them, hence their common name “fluted scales”. In the present study, *Crypticeria multicastrices* Kondo & Unruh and *Crypticeria genistae* (Hempel) are reported for the first time from Ecuador. The two species of fluted scales were found to cause outbreaks in urban green areas in Guayas province on the Ecuadorian coast, attacking native and alien plants. Eighty-five and eleven new host plant species were recorded for *C. multicastrices* and *C. genistae*, respectively. Both invasive fluted scales prefer hosts in the family Fabaceae. No significant differences in the infestation levels of *C. multicastrices* and *C. genistae* were found between native and alien host-plant species. In general, *C. multicastrices* prefers trees as hosts, whereas *C. genistae* prefers herbaceous plants and shrubs. Both species are considered serious pests in urban green areas, associated with sooty molds, yellowing of leaves, and, in some cases, tree dieback. Management strategies to control the fluted scales are discussed briefly.

Keywords: Coccothraupidae, fluted scales, host plants, infestation level, Sternorrhyncha, urban green areas.

Resumen: El género de insectos escama *Crypticeria* Cockerell, 1895 (Hemiptera: Coccothraupidae: Monophlebidae: Iceryini), se distribuye principalmente en el Nuevo Mundo e incluye numerosas especies de plagas a pesar de ser un grupo relativamente pequeño. Los ovisacos, en las especies que los producen, tienen canales o surcos longitudinales, de ahí su nombre común “cochinillas acanaladas”. En el presente estudio, *Crypticeria multicastrices* Kondo & Unruh y *Crypticeria genistae* (Hempel) (Hemiptera: Coccothraupidae: Monophlebidae) se reportan por primera vez en Ecuador. Las dos especies se encontraron causando brotes poblacionales en áreas verdes urbanas de la provincia de Guayas en la costa ecuatoriana, donde atacan plantas nativas y exóticas. Se identificaron 85 y 11 nuevos registros de plantas hospedantes para *C. multicastrices* y *C. genistae*, respectivamente. Las especies de plantas hospedadoras preferidas para ambas escamas acanaladas invasoras pertenecen a la familia Fabaceae. No se encontraron diferencias significativas en el nivel de infestación por *C. multicastrices* y *C. genistae* entre especies de plantas hospedantes nativas y exóticas. En general, *C. multicastrices* prefiere los árboles como hospedantes, mientras que *C. genistae* prefiere las plantas arvenses y los arbustos. Ambas especies se consideran plagas importantes en las áreas verdes urbanas, asociadas con fumagina, el amarillamiento de las hojas e incluso la muerte regresiva de los árboles. Por último, se discuten brevemente las estrategias de manejo para controlar las escamas acanaladas.

Palabras clave: áreas verdes urbanas, Coccothraupidae, escamas acanaladas, nivel de infestación, plantas hospedantes, Sternorrhyncha.



Introduction

Fluted scales or iceryine scale insects belong to the tribe Iceryini within the family Monophlebidae (Hemiptera: Coccomorpha) (Unruh & Gullan, 2008). There are 88 species of iceryine scale insects in five genera: *Crypticerya* Cockerell (28 spp.), *Gigantococcus* Pesson and Bielenin (19 spp.), *Icerya* Signoret (38 spp.), *Echinicerya* Morrison (1 sp.), and *Gueriniella* Fernald (2 spp.) (García Morales et al., 2022). Iceryine scale insects include many polyphagous species. Human activities have introduced species of *Crypticerya* and *Icerya* to new habitats where some of them have become invasive. In South America, several polyphagous species, i.e., *Crypticerya brasiliensis* (Hempel), *C. genistae* (Hempel), *C. montserratensis* (Riley & Howard), *C. multicastrices* Kondo & Unruh, *C. palmeri* (Riley & Howard), *C. zeteki* (Cockerell), *Icerya purchasi* Maskell, and *I. seychellarum* (Westwood) have been reported to cause damage to plant species of economic importance (Kondo et al., 2012; Kondo, Gullan, et al., 2016; Kondo, Ramos-Portilla, et al., 2016; Ramos et al., 2017). The damage caused by fluted scales is divided into direct damage, consisting of the loss of water and nutrients in plant sap due to scale feeding activity, and indirect damage due to the development of sooty mold fungi on the honeydew deposits produced by these insects (Kondo, Becerra et al., 2014).

In June 2021, the first author detected infestations by two unknown species of *Crypticerya* in several urban green areas in Guayaquil city (Guayas Province, Ecuadorian Coast). However, the identities and infestation levels of these alien species remained unconfirmed. The main goal of this study is to identify the two unknown invasive fluted scales at the species level. Furthermore, a list of host plants infested by each of the two species, with an estimated infestation level on the host by each species, is provided. Finally, some suggestions on the possible management of these invasive species are discussed.

Materials and methods

Study area

The study took place in 29 urban green areas in three cities in Guayas, a province located on the Ecuadorian Coast: Guayaquil city (79°52'W, 02°10'S, ca. 11 m altitude), Samborondón (79°43'W, 01°57'S, ca. 23 m altitude), and Daule (79°58'W, 01°52'S, ca. 9 m altitude). The locations of the urban green areas sampled are shown in Figure 1. The map of the studied area was prepared using ArcGIS (version 10.4). The climate in Guayas is characterized by a mean annual rainfall of 1,030 mm, 85 % mean relative humidity, and 26 °C mean annual temperature (Instituto Oceanográfico y Antártico de la Armada [INOCAR], 2021). Usually, a well-defined wet season occurs from January to April, while the dry season occurs from May to December (INOCAR, 2021). The predominant natural vegetation is tropical dry forest, mangroves, and semi-arid shrubland. Urban green areas in the cities of Guayas are characterized by the presence of both alien and native plant species, mainly of the families Fabaceae, Malvaceae, Bignoniaceae, Meliaceae, Burseraceae, and Rubiaceae (Molina-Moreira et al., 2015).

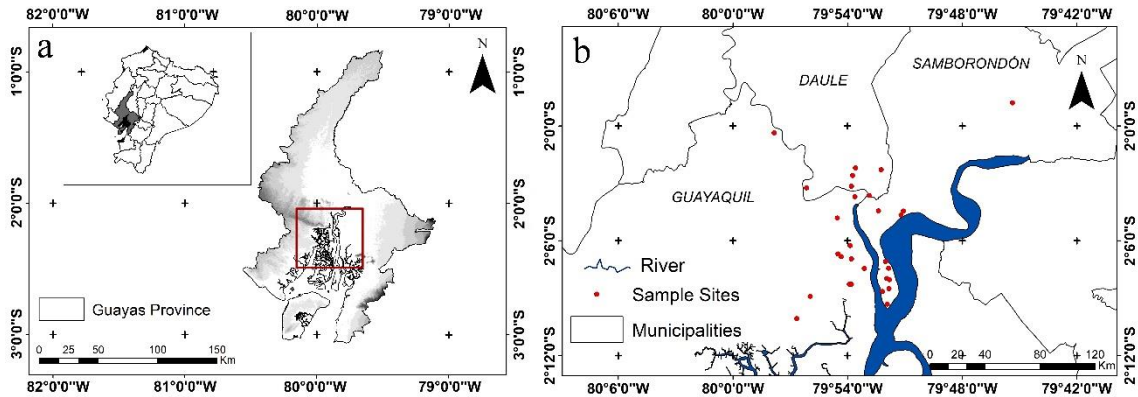


Figure 1. Study area and sampling points to determine infestation levels and host plants of two *Crypticerya* species. **a.** A map showing the location of Guayas in Ecuador (top left, inset) and the study area in Guayas, Ecuador (red rectangle). **b.** A larger-scale map showing the locations of the sample sites in Guayaquil, Samborondón, and Daule.

Source: Elaborated by the authors using ArcGIS (version 10.4).

Taxonomic identification

For each host plant, about 25-30 individuals of the fluted scale species in different developmental stages were collected from urban green areas in Guayaquil, Daule, and Samborondón. The samples were collected into plastic bags and transported to the laboratory. The specimens were preserved in 70 % ethanol. For species identification, some adult female specimens of each species were slide-mounted using the method of Sirisena et al. (2013), with a single specimen on each slide. Voucher specimens are deposited in the Entomological Collection of the Agrocalidad Laboratory, Manta, Ecuador.

Species were identified using the taxonomic keys by Kondo et al. (2012) and Kondo, Gullan, et al. (2016), resulting in the identification of two species. The identifications were verified against the diagnoses of *C. multicatrices* in Kondo & Unruh (2009) and Sotelo & Kondo (2016), and *C. genistae* in Mestre-Novoa et al. (2016) and Miller et al. (2014).

Identification of host plants

Most plant hosts were identified *in situ* with the mobile app Pl@ntnet (Goëau et al., 2013). Samples of host plants that could not be identified *in situ* were collected, taking, in some cases, a photographic record of flowers, fruit, stems, and leaves. Plant samples were compared with the descriptions and bibliography of Cisneros-Bohórquez & Molina-Moreira (2017), Palacios (2016a, b), and Molina-Moreira et al. (2015). Scientific names were verified using the database “The Missouri Botanical Garden’s VAST - Vascular Tropicos” (Tropicos, 2021). Plants were also recorded according to their growth habit, i.e., climbing plants, herbaceous plants, shrubs, trees, and palms.

Determination of infestation levels of fluted scales

Infestation levels of the two fluted scale species on the host plants were determined *in situ* from “snapshot” observations made by the authors in the field from July to October 2021. A simple way to assess the levels of infestation was used (Kondo et al., 2012): (i) No infestation: Zero individuals of the fluted scale present; (ii) Low: From one to several fluted scale individuals on leaves, branches, or other plant parts; (iii) Medium: High populations of fluted scales on leaves, branches, but without apparent symptoms of damage to the plant; and (iv) High: Leaves or branches highly infested, with symptoms of plant damage, e.g., sooty molds, yellowing of leaves, dried branches or dieback.

A Chi-square test and analysis of standardized residuals (*s.r.*) were used to analyze the data on infestation levels (low, medium, and high). Data analysis was carried out using the statistical software R run in R Studio (R Studio Team, 2019).

Results and discussion

The two fluted scale species recorded were found to belong to the species *Crypticerya genistae* (Hempel) and *C. multicastrices* Kondo & Unruh; both are new records for Ecuador. According to Kondo, Gullan, et al. (2016), *C. genistae* is native to South America and probably originated in Brazil, where it was described over 100 years ago. The soybean fluted scale, *C. genistae*, has been reported from 17 countries in the New World: North America (Florida), Central America (Mexico), 13 Caribbean islands, and South America (Brazil and Colombia) (García Morales et al., 2022), and accidentally introduced to West Africa (countries not specified) (Malumphy, 2014).

The Colombian fluted scale, *C. multicastrices*, is native to continental Colombia and, in 2010, was reported as invasive species on San Andrés and Old Providence Islands (Colombia) (Kondo et al., 2012; Kondo, Gullan et al. 2014). The species commonly infests branches and leaves of its hosts but may occur on the tree trunk and fruits when populations are high. Between 2010 and early 2013, damage caused by *C. multicastrices* resulted in the loss of competitiveness and profitability in the agricultural sector of San Andrés Island, decreasing the quality of life of native families (Kondo, Becerra et al., 2014).

Host plants and infestation levels recorded

Crypticerya genistae

One hundred host-plant species belonging to 77 genera in 22 families have been reported as hosts for *C. genistae* (García Morales et al., 2022; Mestre-Novoa et al., 2016). In the present study, *C. genistae* was recorded on 13 host-plant species. Of these, eight belong to the family Fabaceae, the others to Asteraceae, Lamiaceae, Onagraceae, and Nyctaginaceae (Table 1). Eleven of these species are new host plant records for *C. genistae*. Among the host plants recorded in the study, eight species are native, whereas five species are alien to Ecuador (Table 1). Most of the recorded

hosts of *C. genistae* are herbaceous (nine species), a few are trees (three species), and only one species is a shrub (Table 1). This result suggests that herbaceous plants are the preferred hosts for *C. genistae*.

Previous studies in Cuba, Florida (USA), and Guadeloupe in the Caribbean (France) reported that preferred hosts of *C. genistae* belong to the families Asteraceae, Euphorbiaceae, and, particularly, Fabaceae (Etienne & Matile-Ferrero, 2008; Hodges et al., 2008; Mestre-Novoa et al., 2016). Besides these host-plant families, the Malvaceae and Solanaceae also are common hosts of *C. genistae* (Kondo, Gullan, et al., 2016).

Table 1. Host plants of *Crypticerya genistae* recorded in Guayas, Ecuador

Host-plant species	Family	Origin	Growth habit	Infestation level
* <i>Albizia multiflora</i> (Kunth) Barneby & JW.	Fabaceae	N	T	LI
* <i>Boerhavia coccinea</i> Mill.	Nyctaginaceae	N	H	MI
* <i>Caesalpinia glabrata</i> Kunth	Fabaceae	N	T	HI
* <i>Cassia siamea</i> (Lam.) H.S. Irwin & Barneby	Fabaceae	A	T	HI
* <i>Cyanthillium cinereum</i> (L.) H. Rob.	Asteraceae	A	H	MI
* <i>Desmodium triflorum</i> (L.) DC.	Fabaceae	N	H	MI
<i>Indigofera suffruticosa</i> Mill.	Fabaceae	N	H	MI
* <i>Lathyrus sphaericus</i> Retz	Fabaceae	A	H	LI
<i>Ludwigia peruviana</i> (L.) H. Hara	Onagraceae	N	H	MI
* <i>Neptunia plena</i> (L.) Benth	Fabaceae	N	H	HI
* <i>Senna reticulata</i> (Willd.) H. S. Irwin & Barneby	Fabaceae	N	S	HI
* <i>Ocimum</i> sp.	Lamiaceae	A	H	HI
* <i>Origanum majorana</i> L.	Lamiaceae	A	H	LI

Note. Plant origin codes: **A**: Alien species; **N**: Native species. Growth habit codes: **H**: Herbaceous, **S**: Shrub, **T**: Tree. Infestation level codes: **LI**: Low Infestation, **MI**: Medium Infestation, **HI**: High Infestation. * = New host-plant record for *C. genistae*.

In Florida, where *C. genistae* is an alien invasive species, 47 hosts for this scale species have been reported (Hodges et al., 2008). In Cuba, *C. genistae* has been collected from 23 host species (Mestre-Novoa et al., 2016). This study found 11 new host-plant records for *C. genistae* (Table 1).

Native and alien plant species did not differ significantly in their infestation levels ($X^2 = 1.73$; $p = 0.42$; $d.f. = 2$), and infestation levels were not significantly different between growth habits either ($X^2 = 4.81$; $p = 0.30$; $d.f. = 4$). Herbaceous species tended to have higher infestation levels compared to other growth habits. The host species with the highest levels of infestation were

Caesalpinia glabrata, *Cassia siamea*, *Neptunia plena*, *Senna reticulata* (Fabaceae), and one undetermined species of Lamiaceae, *Ocimum* sp.

Some host plants (native and alien) with different levels of infestation by *C. multicastrices* and *C. genistae* are shown in Figure 2.

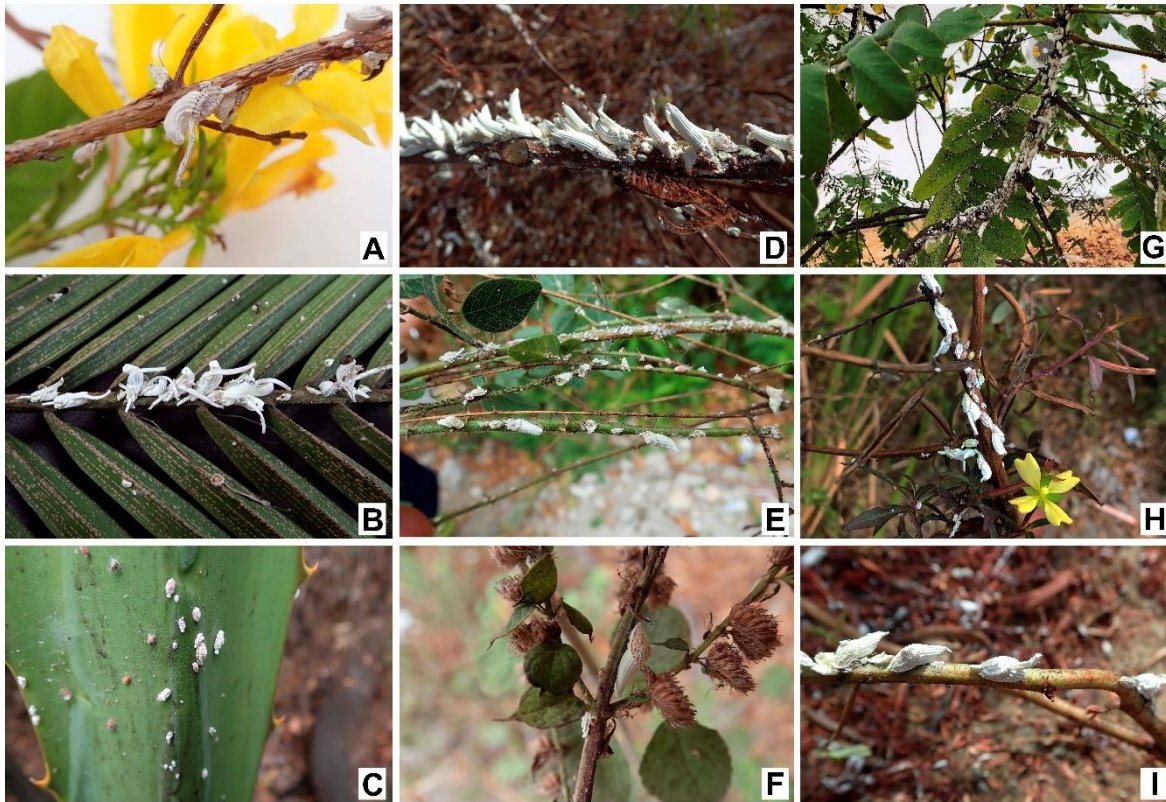


Figure 2. Examples of levels of infestation (High: HI; Medium: MI; Low: LI) on some host species of *C. multicastrices* and *C. genistae*. Host plants for *C. multicastrices*: **A.** *Tecoma castanifolia* (HI); **B.** *Adonidia merrillii* (MI); **C.** *Agave americana* (LI). Host plants for *C. genistae*: **D.** *Neptunia plena* (HI); **E.** *Desmodium triflorum* (MI); **F.** *Origanum majorana* (LI). Host plants for both *C. multicastrices* and *C. genistae*: **G.** *Senna reticulata*; **H.** *Boerhavia coccinea*; **I.** *Ludwigia peruviana*
Source: A-F and I by T. Kondo, G-H by M. Arias

Crypticerya multicastrices

A total of 148 host-plant species belonging to 53 genera in 118 families have been reported as hosts for *C. multicastrices* (García Morales et al., 2022; Sotelo & Kondo, 2016). In the present study, we identified 111 host-plant species belonging to 50 families as hosts of this species (Table 2). The families Fabaceae, Arecaceae, and Araceae had the most significant number of host-plant species, with 21 species (18.9 %), ten species (9 %), and seven species (6.3 %), respectively. The other plant families had from one to four plant species each. Of the host plants, 54 % (60 species) are of alien origin, whereas 46 % (51 species) are native to Ecuador. Most hosts are trees (44 %; 49 species), followed by herbaceous plants (34 %; 38 species).

On San Andrés, Old Providence, and Santa Catalina Islands (Colombia), where *C. multicastrices* is an alien invasive species, 147 host-plant species have been recorded for this scale insect (Kondo et al., 2012; Kondo, Gullan et al., 2014; Silva-Gómez et al., 2013). This study records 85 additional host-plant species for *C. multicastrices* (Table 2). One of the studied locations was the Jardín Botánico de Guayaquil, which contains many alien plant species from different regions. In this location, *C. multicastrices* was found infesting a wide variety of alien host plants, e.g., *Mimusops coriacea*, native to Madagascar; *Licania tomentosa*, native to Brazil; *Mespilus germanica*, native to western Asia; and *Pistacia vera* and *Streblus indicus*, native to China.

Table 2. Host plants of *Crypticeria multicastrices* recorded in Guayas, Ecuador.

Host-plant species	Family	Origin	Growth habit	Infestation level
<i>Adonidia merrillii</i> (Becc.) Becc.	Arecaceae	A	P	MI
* <i>Agave americana</i> L.	Agavaceae	A	H	LI
* <i>Aglaonema commutatum</i> Schott	Araceae	A	H	LI
* <i>Albizia pistaciifolia</i> (Willd.) Barneby & J.W.Grimes	Fabaceae	N	T	HI
* <i>Ananas lucidus</i> Mill.	Bromeliaceae	N	H	LI
<i>Annona cherimola</i> Mill.	Annonaceae	N	T	HI
<i>Annona muricata</i> L.	Annonaceae	N	T	HI
* <i>Anthurium crassinervium</i> (Jacq.) Schott.	Araceae	A	H	MI
* <i>Anthurium andraeanum</i> Linden	Araceae	N	H	MI
* <i>Asparagus densiflorus</i> (Kunth) Jessop	Asparagaceae	A	H	LI
* <i>Azadirachta indica</i> A. Juss.	Meliaceae	A	T	MI
* <i>Bauhinia forficata</i> Link.	Fabaceae	A	T	HI
* <i>Boerhavia coccinea</i> Mill.	Nyctaginaceae	N	H	MI
* <i>Bucida buceras</i> L.	Combretaceae	A	T	HI
* <i>Caesalpinia glabrata</i> Kunth	Fabaceae	N	T	LI
* <i>Callistemon citrinus</i> (Curtis) Skeels.	Myrtaceae	A	T	HI
* <i>Canna indica</i> L.	Cannaceae	N	H	LI
* <i>Capparis flexuosa</i> (L.) L.	Capparaceae	N	S	LI
<i>Carica papaya</i> L.	Caricaceae	N	H	MI
<i>Cassia fistula</i> L.	Fabaceae	A	T	MI
* <i>Cassia siamea</i> (Lam.) H.S. Irwin & Barneby	Fabaceae	A	T	HI
<i>Cecropia peltata</i> L.	Urticaceae	N	T	HI
* <i>Chamaedorea seifrizii</i> Burret	Arecaceae	A	P	MI
<i>Chrysophyllum cainito</i> L.	Sapotaceae	N	T	HI
<i>Citrus reticulata</i> Blanco	Rutaceae	A	T	HI
<i>Citrus sinensis</i> (L.) Osbeck.	Rutaceae	A	T	HI
<i>Citrus x limon</i> L.	Rutaceae	A	S	HI
* <i>Cochlospermum vitifolium</i> (Willd.) Spreng.	Bixaceae	N	T	HI
<i>Coccoloba uvifera</i> (L.) L.	Polygonaceae	N	T	HI
* <i>Commelina diffusa</i> Burm.	Commelinaceae	N	H	LI
* <i>Cordia alliodora</i> (Ruiz & Pav.) Oken	Boraginaceae	N	T	MI
* <i>Cordia lutea</i> Lam.	Boraginaceae	N	S	HI

* <i>Cordia macrantha</i> Chodat	Boraginaceae	N	T	LI
* <i>Cycas circinalis</i> L.	Cycadaceae	A	P	MI
* <i>Cycas revoluta</i> Thunb.	Cycadaceae	A	P	MI
* <i>Cyperus papyrus</i> L.	Cyperaceae	A	H	LI
<i>Delonix regia</i> (Bojer ex Hook.) Raf.	Fabaceae	A	T	HI
* <i>Desmodium incanum</i> (L.) DC.	Fabaceae	N	H	LI
* <i>Desmodium triflorum</i> (L.) DC.	Fabaceae	N	H	LI
* <i>Dieffenbachia seguine</i> (Jacq.) Schott.	Araceae	N	H	HI
* <i>Dypsis leptocbeilos</i> (Hodel) Beentje & J. Dransf.	Arecaceae	A	P	LI
<i>Dypsis lutescens</i> (H.Wendl.) Beentje & J. Dransf.	Arecaceae	A	P	MI
* <i>Entada polystachya</i> (L.) DC.	Fabaceae	N	C	MI
* <i>Erigeron bonariensis</i> L.	Asteraceae	N	H	LI
* <i>Erythrina smithiana</i> Kruckoff	Fabaceae	N	T	HI
* <i>Euphorbia tirucalli</i> L.	Euphorbiaceae	A	H	MI
<i>Ficus benjamina</i> L.	Moraceae	A	T	HI
<i>Ficus lyrata</i> Warb.	Moraceae	A	T	HI
* <i>Ficus maxima</i> Mill.	Moraceae	N	T	LI
<i>Gliricidia sepium</i> (Jacq.) Kunth ex Walp.	Fabaceae	A	T	MI
* <i>Gustavia angustifolia</i> Benth.	Lecythidaceae	N	S	HI
* <i>Handroanthus heterophylla</i> (DC.) Britton	Bignoniaceae	A	T	MI
* <i>Handroanthus rosea</i> (Bertol.) DC.	Bignoniaceae	N	T	HI
* <i>Handroanthus caraiba</i> (Mart.) Mattos	Bignoniaceae	A	T	MI
* <i>Heliconia bibai</i> L.	Heliconiaceae	A	H	HI
* <i>Heliconia rostrata</i> Ruiz & Pav.	Heliconiaceae	N	H	HI
* <i>Heptapleurum arboricola</i> Hayata	Araliaceae	A	H	HI
<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	A	S	MI
* <i>Ipomoea triloba</i> L.	Convolvulaceae	A	H	MI
* <i>Jacaranda mimosifolia</i> D. Don	Bignoniaceae	A	T	HI
* <i>Justicia</i> sp.	Acanthaceae	A	H	MI
* <i>Lantana camara</i> L.	Verbenaceae	N	H	MI
<i>Licania tomentosa</i> (Benth.) Fritsch.	Chrysobalanaceae	A	T	LI
* <i>Lippia alba</i> (Mill.) N.E.Br. ex Britt & Wilson	Verbenaceae	N	H	HI
* <i>Ludwigia octovalvis</i> (Jacq.) P.H. Raven	Onagraceae	N	H	MI
* <i>Ludwigia peruviana</i> (L.) H. Hara	Onagraceae	N	H	MI
* <i>Machaerium millei</i> Standl.	Fabaceae	N	T	HI
<i>Mammea americana</i> L.	Clusiaceae	A	T	MI
<i>Mangifera indica</i> L.	Anacardiaceae	A	T	HI
* <i>Mespilus germanica</i> L.	Rosaceae	A	T	HI
* <i>Mimosa acantholoba</i> (Humb. & Bonpl. ex Willd.) Poir.	Fabaceae	N	T	HI
* <i>Mimosa debilis</i> Humb. & Bonpl. ex Willd.	Fabaceae	N	H	HI
* <i>Mimusops coriacea</i> (A. DC) Miq.	Sapotaceae	A	T	HI
* <i>Momordica charantia</i> L.	Cucurbitaceae	A	H	LI
* <i>Monstera borsigiana</i> K. Koch	Araceae	A	H	HI

* <i>Muntingia calabura</i> L.	Muntingiaceae	N	T	HI
* <i>Murraya paniculata</i> (L.) Jack	Rutaceae	A	S	HI
* <i>Neptunia plena</i> (L.) Benth.	Fabaceae	N	H	HI
* <i>Passiflora foetida</i> L.	Passifloraceae	N	H	MI
<i>Persea americana</i> Mill.	Lauraceae	A	T	MI
<i>Phaseolus</i> sp.	Fabaceae	N	H	HI
* <i>Phoenix canariensis</i> Wildpret	Arecaceae	A	P	MI
<i>Phoenix roebelenii</i> O'Brien	Arecaceae	N	P	HI
* <i>Piper aduncum</i> L.	Piperaceae	N	S	MI
* <i>Piscidia carthagenensis</i> Jacq.	Fabaceae	N	T	HI
* <i>Pistacia vera</i> L.	Anacardiaceae	A	T	HI
* <i>Pithecellobium excelsum</i> (Kunth) Mart.	Fabaceae	N	T	LI
* <i>Polyscias guilfoylei</i> (W. Bull) L.H. Bailey	Araliaceae	A	S	HI
* <i>Polygonum aviculare</i> L.	Polygonaceae	A	H	LI
* <i>Portulaca grandiflora</i> Hook.	Portulacaceae	A	H	MI
* <i>Pradosia montana</i> T.D. Penn.	Sapotaceae	N	T	HI
* <i>Prosopis juliflora</i> (Sw.) DC.	Fabaceae	N	T	MI
<i>Psidium guajava</i> L.	Myrtaceae	N	T	HI
* <i>Rhapis excelsa</i> (Thunb.) A. Henry	Arecaceae	A	P	HI
* <i>Rhizophora mangle</i> L.	Rhizophoraceae	N	T	LI
* <i>Roystonea oleracea</i> (Jacq.) O.F. Cook	Arecaceae	A	P	HI
* <i>Roystonea regia</i> (Kunth) O.F. Cook	Arecaceae	A	P	HI
* <i>Ruellia tuberosa</i> L.	Acanthaceae	A	H	MI
<i>Samanea saman</i> (Jacq.) Merr.	Fabaceae	A	T	HI
* <i>Sapindus saponaria</i> L.	Sapindaceae	N	T	HI
* <i>Senna reticulata</i> (Willd.) H.S. Irwin & Barneby	Fabaceae	N	S	MI
* <i>Spathiphyllum wallisii</i> Regel	Araceae	A	H	LI
* <i>Streblus indicus</i> (Bureau) Corner	Moraceae	A	T	LI
* <i>Syngonium podophyllum</i> Schott	Araceae	N	H	LI
* <i>Tecoma castaneifolia</i> (D. Don) Melch.	Bignoniaceae	N	S	HI
<i>Tectona grandis</i> L. F.	Lamiaceae	A	T	HI
* <i>Triplaris cumingiana</i> Fisch. & C.A. Mey.	Polygonaceae	N	T	MI
* <i>Turnera ulmifolia</i> L.	Turneraceae	A	H	HI
* <i>Typha angustifolia</i> L.	Typhaceae	A	H	LI
* <i>Wodyetia bifurcata</i> A.K. Irvine	Arecaceae	A	P	HI
* <i>Zamia furfuracea</i> Aiton	Zamiaceae	A	P	MI

Note. Plant origin codes: **A:** Alien species; **N:** Native species. Growth habit codes: **C:** Climbing plant, **H:** Herbaceous, **P:** Palm, **S:** Shrub, **T:** Tree. Infestation level codes: **LI:** Low Infestation, **MI:** Medium Infestation, **HI:** High Infestation. * = New host-plant record for *C. multicastrices*.

Although the introduced tree *Terminalia catappa* is frequent in the green areas studied (I. Herrera, personal observation), *C. multicastrices* does not infest this plant, which is consistent with observations on San Andrés Island by Kondo et al. (2012), who reported no incidence of *C. multicastrices* on *T. catappa*. An *in vitro* experimental study conducted by Redo et al. (2019) determined that the water-ethanol fraction of *T. catappa* leaf possesses high biolarvicidal activity

against third-instar larvae of *Aedes aegypti*. Studies that detect the effects of chemical components of *T. catappa* on *C. multicastrices* are needed to elucidate the resistance mechanism of *T. catappa* against infestations by *C. multicastrices*.

Of the total of host-plant species of *C. multicastrices* detected, 47 % (53 species) had high levels of infestation, 30.6 % (34 species) had medium levels of infestation, and 21.6 % (24 species) had low levels of infestation. No significant differences in the infestation levels between native and alien species ($X^2 = 1.49$; $p = 0.5$; $d.f. = 2$) were found. The infestation level was significantly different between plant growth habits ($X^2 = 22.36$; $p = 0.004$; $d.f. = 8$). Herbaceous plant species had a low level of infestation by *C. multicastrices* compared to trees and palms and other growth habits ($s.r. = 2.37$; $p < 0.05$).

Several plants had a higher level of infestation than others (Table 2). These host plants are leguminous species *Albizia pistaciifolia*, *Samanea saman*, and *Cassia siamea*; fruit trees *Mangifera indica*, *Psidium guajava*, *Citrus sinensis*, *C. reticulata*, *Annona muricata*, and *A. cherimola*; and palms *Phoenix roebelenii*, *Wodyetia bifurcata*, and *Roystonea oleracea*. Kondo, Becerra et al. (2014) also reported on San Andrés Island (Colombia) that the highest level of infestation by *C. multicastrices* occurred on palms, various fruit trees, and leguminous trees and shrubs.

We detected high levels of infestation by *C. multicastrices* on *Pradosia montana* (Sapotaceae) and *Erythrina smithiana* (Fabaceae), both endemic to Ecuador; *E. smithiana* is categorized as “endangered” (Neill, 2017). Future studies are needed to monitor the potential impact of *C. multicastrices* on *E. smithiana* populations.

Considerations for management

Urban green areas promote human well-being (Bertram & Rehdanz, 2015) and are necessary for mitigating the effects of climate change in cities (Nero et al., 2017). *Crypticeria* species can reduce the photosynthetic rate of infested plants and cause defoliation and death of the host (Kondo et al., 2012), significantly affecting vegetal cover in urban green areas. Management of the invasion by *C. multicastrices* and *C. genistae* is necessary to avoid the loss of the benefits that urban green areas provide to citizens. Control of invasive species includes prevention, eradication, and containment.

Interrupting the dispersal pathway(s) is necessary to prevent new introductions of these invasive fluted scale species to non-infested areas. Kondo et al. (2012) suggested that the introduction of *C. multicastrices* to San Andrés Island occurred through the transport of infested ornamental plants from continental Colombia. It is probable that trade in ornamental plants and ineffective pest control in local nurseries facilitated the introduction and spread of *C. multicastrices* and *C. genistae* in Guayaquil, Samborondón, and Daule. Hence, it is essential to devise protocols that strengthen the control of these two species of fluted scales during trade in ornamental plants and the effectiveness of pest control on plants in local nurseries. Another prevention strategy is to plant a wide variety of trees and shrubs belonging to different plant families in urban green areas to include plants resistant to the fluted scales.

Biological control has been suggested as the most effective strategy for eradicating invasive *Crypticerya* species (Etienne & Matile-Ferrero, 2008; Gaimari et al., 2012; González et al., 2012; Kondo et al., 2012). In neighboring Colombia, many natural enemies of *C. multicastrices* have been reported, including an entomopathogenic fungus, *Isaria* sp. (Fungi: Eurotiales: Trichocomaceae); predators including ladybird beetles, i.e., *Delphastus quinculus* Gordon, *Diomus seminulus* (Mulsant), *Novius cardinalis* (Mulsant), and *N. punicus* (Gordon) (Coleoptera: Coccinellidae); a predatory fly, *Syneura cocciphila* (Coquillet) (Diptera: Phoridae); two species of predatory lacewings, *Chrysoperla* sp., and *Ceraeochrysa* sp. (Neuroptera: Chrysopidae); a parasitoid wasp, *Brethsiella* cf. *abnormicornis* (Girault); and a hyperparasitoid wasp, *Cheiloneurus* sp. (Hymenoptera: Encyrtidae) (Kondo, Ramos-Portilla, et al., 2016). Many of these insects may also likely occur in Ecuador because of the two countries' proximity.

Although many native host-plant species are found in the dry forests adjacent to Guayaquil, Samborondón, and Daule, the invasion of *C. multicastrices* and *C. genistae* is restricted to urban green areas, implying the presence of natural enemies in the dry forest in the study area that could be used as biological control agents. Further studies are required to identify the natural enemies of both invasive species in this dry forest.

On the other hand, the use of pesticides to control invasive *Crypticerya* species has been reported as counterproductive in the mid- and long term because they reduce populations of the natural enemies (Kondo et al., 2012). Early detection and rapid response through systematic surveillance of urban green areas are required to prevent infestations by *C. multicastrices* and *C. genistae*. Infestations by *Crypticerya* species are generally more frequent during the dry season (Kondo et al., 2012); thus, the surveillance of urban green areas should be more frequent and thorough during this season.

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Disclaimers

All the authors made significant contributions to the document, agree with its publication, and state no conflicts of interest in this study.

References

Bertram, C., & Rehdanz, K. (2015). The role of urban green space for human well-being. *Ecological Economics*, 120, 139-152. <https://doi.org/10.1016/j.ecolecon.2015.10.013>

- Cisneros Bohórquez, J., & Molina-Moreira, N. (2017). *Evaluación del Bosque Seco tropical del Parque Histórico Guayaquil*. Investigatio N° 9, 1-27. Universidad Espiritu Santo-Ecuador. <https://doi.org/10.31095/investigatio.2017.9.1>
- Etienne, J., & Matile-Ferrero, D. (2008). *Crypticerya genistae* (Hempel), nouveau danger en Guadeloupe (Hemiptera, Coccoidea, Monophlebidae). *Bulletin de la Société Entomologique d'Egypte*, 113(4), 517-520. <https://doi.org/10.3406/bsef.2008.3052>
- Gaimari, S. D., Quintero, E. M., & Kondo, T. (2012). First report of *Syneura cocciphila* (Coquillett, 1895) (Diptera: Phoridae), as a predator of the fluted scale *Crypticerya multicastrices* Kondo & Unruh, 2009 (Hemiptera: Monophlebidae). *Boletín del Museo de Entomología de la Universidad del Valle*, 13(2), 26-28. https://drive.google.com/file/d/1OE5Aes-PC8AAu_vSQu88hZbY4eVZKHd8/view
- García Morales, M., Denno, B., Miller, D., Miller, G., Ben-Dov, Y., & Hardy, N. (2022). *ScaleNet: A literature-based model of scale insect biology and systematics*. Database. <https://doi.org/10.1093/database/bav118>
- Goëau, H., Bonnet, P., Joly, A., Bakić, V., Barbe, J., Yahiaoui, I., & Péronnet, A. (2013, October). Pl@ntnet mobile app (pp. 423-424). In *Proceedings of the 21st ACM international conference on Multimedia*. <https://doi.org/10.1145/2502081.2502251>
- González, G., López Bermúdez, R., & Kondo, T. (2012). First report of *Delphastus quinclus* Gordon and *Diomus seminulus* (Mulsant) (Coleoptera: Coccinellidae) feeding on eggs and first-instar nymphs of *Crypticerya multicastrices* Kondo and Unruh (Hemiptera: Monophlebidae). *Insecta Mundi*, 0268, 1-6. <https://journals.flvc.org/mundi/article/view/0268>
- Hodges, G. S., Hodges, A. C., & Unruh, C. M. (2008). A new exotic pest for Florida's natural areas: *Crypticerya genistae* (Hemiptera: Monophlebidae). *Florida Entomologist*, 91(2), 335-337. [https://doi.org/10.1653/0015-4040\(2008\)91\[335:ANEPFF\]2.0.CO;2](https://doi.org/10.1653/0015-4040(2008)91[335:ANEPFF]2.0.CO;2)
- Instituto Oceanográfico y Antártico de la Armada (INOCAR). (2021). *Precipitaciones Guayaquil*. <https://www.inocar.mil.ec/web/index.php/precipitacion-en-guayaquil> [Accessed: December 6, 2021]
- Kondo, T., & Unruh, C. M. (2009). A new species of *Crypticerya* Cockerell (Hemiptera: Monophlebidae) from Colombia, with a key to species of the tribe Iceryini found in South America. *Neotropical Entomology*, 38(1), 92-100. <https://doi.org/10.1590/S1519-566X2009000100009>
- Kondo, T., Becerra, C. G., Quintero, E. M., & Manrique, M. B. (2014). Distribución y niveles de infestación de *Crypticerya multicastrices* Kondo y Unruh (Hemiptera: Monophlebidae) en la isla de San Andrés. *Corpoica-Ciencia y Tecnología Agropecuaria*, 15(1), 63-72. https://doi.org/10.21930/rcta.vol15_num1_art:397
- Kondo, T., Gullan, P., & González, G. (2014). An Overview of a fortuitous and efficient biological control of the Colombian fluted scale, *Crypticerya multicastrices* Kondo & Unruh (Hemiptera: Monophlebidae: Iceryini), on San Andres Island, Colombia. *Acta Zoologica Bulgarica*, Suppl., 6, 87-93. <https://www.acta-zoologica-bulgarica.eu/downloads/acta-zoologica-bulgarica/2014/supplement-6-87-93.pdf>
- Kondo, T., Gullan, P., & Ramos Portilla, A. A. (2012). Report of new invasive scale insects (Hemiptera: Coccoidea), *Crypticerya multicastrices* Kondo & Unruh (Monophlebidae) and *Maconellicoccus hirsutus* (Green) (Pseudococcidae), on the islands of San Andres and Providencia, Colombia, with an updated taxonomic key to iceryine scale insects of South America. *Insecta Mundi*, 0265, 1-17. <https://journals.flvc.org/mundi/article/view/0265>

- Kondo, T., Gullan, P. J., Peronti, A. L. B. G., Ramos-Portilla, A. A., Caballero, A., & Pretelt, N. V. (2016). First records of the iceryine scale insects *Crypticerya brasiliensis* (Hempel) and *Crypticerya genistae* (Hempel) (Hemiptera: Monophlebidae) for Colombia. *Insecta Mundi*, 0480, 1-9. <https://journals.flvc.org/mundi/article/view/0480>
- Kondo T., Ramos-Portilla, A. A., Peronti, A. L. B. G., & Gullan, P. J. (2016). Known distribution and pest status of fluted scale insects (Hemiptera: Monophlebidae: Iceryini) in South America. *Redia*, XCIX, 187-195 <http://dx.doi.org/10.19263/REDIA-99.16.24>
- Malumphy, C. (2014). An annotated checklist of scale insects (Hemiptera: Coccoidea) of Saint Lucia, Lesser Antilles. *Zootaxa*, 3846(1), 69-86. <https://doi.org/10.11646/zootaxa.3846.1.3>
- Miller, D., Rung, A., Parikh, G., Venable, G., Redford, A. J., Evans, G. A., & Gill, R. J. (2014). *Crypticerya genistae*. Scale Insects, Edition 2. USDA APHIS Identification Technology Program (ITP). <http://idtools.org/id/scales/factsheet.php?name=7063>
- Mestre-Novoa, N., Fontenla Rizo, J. L., Kondo, T., Álvarez de Zayas, A., & Cuervo Reinoso, Z. (2016). *Crypticerya genistae* Hempel (Hemiptera: Monophlebidae) nuevo registro de insecto escama invasor para Cuba. *Fitosanidad*, 20(2), 85-92. <https://www.redalyc.org/pdf/2091/209155169004.pdf>
- Molina-Moreira, N., Lavayen-Tamayo, J., & Fabara-Suárez, M. (2015). *Árboles de Guayaquil*. Universidad Espíritu Santo.
- Nero, B. F., Callo-Concha, D., Anning, A., & Denich, M. (2017). Urban green spaces enhance climate change mitigation in cities of the global south: the case of Kumasi, Ghana. *Procedia Engineering*, 198, 69-83. <https://doi.org/10.1016/j.proeng.2017.07.074>
- Neill, D. (2017). *Erythrina smithiana*. In S. León-Yáñez, R. Valencia, N. Pitmam, L. Endara, C. Ulloa Ulloa, & H. Navarrete (Eds.), *Libro Rojo de Plantas Endémicas del Ecuador*. Publicaciones del Herbario QCA, Pontificia Universidad Católica del Ecuador. <https://bioweb.bio/floraweb/librorojo/FichaEspecie/Erythrina%20smithiana>.
- Palacios, W. A. (2016a). *Árboles del Ecuador, Especies representativas*. Universidad Técnica del Norte, Ministerio del Ambiente del Ecuador, Instituto Nacional de Biodiversidad.
- Palacios, W. A. (2016b). *Árboles del Ecuador, Familias y Géneros*. Universidad Técnica del Norte, Ministerio del Ambiente del Ecuador, Instituto Nacional de Biodiversidad.
- Ramos, A. S. J. C., Peronti, A. L. B. G., Kondo, T., & Lemos, R. N. S. (2017). First record of *Crypticerya zeteki* (Cockerell, 1914) (Monophlebidae) in Brazil and *Maconellicoccus hirsutus* (Green, 1908) (Pseudococcidae) in the state of Maranhão. *Brazilian Journal of Biology*, 78(1), 87-90. <http://dx.doi.org/10.1590/1519-6984.05416>
- Redo, T., Triwani Triwani, C. A., & Salni, S. (2019). Larvicidal activity of Ketapang leaf fraction (*Terminalia catappa* L.) on *Aedes aegypti* instar III. *Open Access Macedonian Journal of Medical Sciences*, 7(21), 3526. <https://doi.org/10.3889/oamjms.2019.760>
- Silva-Gómez, M., Quiroz-Gamboa, J., Yepes, F., Maya, M., Santos, A., & Hoyos-Carvajal, L. (2013). Incidence evaluation of *Crypticerya multicatrices* and *Maconellicoccus hirsutus* in Colombian Seaflower Biosphere Reserve. *Agricultural Sciences*, 4, 654-665. <https://doi.org/10.4236/as.2013.412088>
- Sirisena, U. G., Watson, G. W., Hemachandra, K. S., & Wijayagunasekara, H. N. (2013). A modified technique for the preparation of specimens of Sternorrhyncha for taxonomic studies. *Tropical Agricultural Research*, 24(2), 139-149. <https://www.cabi.org/isc/FullTextPDF/2013/20133156481.pdf>

- Sotelo, P., & Kondo, T. (2016). On the biology of the Colombian fluted scale, *Crypticerya multicatrices* Kondo & Unruh (Hemiptera: Monophlebidae). *Neotropical Entomology*, 46(4), 433-441. <https://doi.org/10.1007/s13744-016-0463-1>
- Tropicos. (2021, December 15). *Tropicos.org*. *Missouri Botanical Garden*. Online database. <https://tropicos.org>
- Unruh, C., & Gullan, P. (2008). Identification guide to species in the scale insect tribe Iceryini (Coccoidea: Monophlebidae). *Zootaxa*, 1803(1), 1-106. <https://doi.org/10.11646/zootaxa.1803.1.1>