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Scientific Note

Armored Scale Insects (Hemiptera: Diaspididae) on *Dypsis lutescens* and *Phoenix roebelenii* (Arecaceae) in Urban Environments of Costa Rica

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Abstract. Armored scales (Hemiptera: Diaspididae) were collected from *Dypsis lutescens* (H. Wendl) Beentje & J. Dransf., 1995, and *Phoenix roebelenii* O'Brien, 1889, in urban Costa Rica. *Lopholeucaspis cockerelli* (Grandpré & Charmoy, 1899), previously known only from intercepted plant material, was found on both palms (*P. roebelenii*—new host record). *Pseudischnaspis bowreyi* (Cockerell, 1893), also previously recorded only from interceptions, was identified on both species (new host records). *Ischnaspis longirostris* (Signoret, 1882) was identified on both palms, *Selenaspidus articulatus* (Morgan, 1889) on *P. roebelenii* (new host record), *Hemiberlesia cyanophylli* Signoret, 1869 on *P. roebelenii* (new host record) and *D. lutescens*, *H. palmae* (Cockerell, 1893) on *P. roebelenii* (new host record) and *D. lutescens*, *Pinnaspis strachani* (Cooley, 1899) on *D. lutescens*, *Pinnaspis apidistrae* (Signoret, 1869) on *D. lutescens* and *P. roebelenii* (new host record), *Diaspis boisduvalii* Signoret, 1869 on *P. roebelenii*, *Chrysomphalus dictyospermi* (Morgan, 1889) on both palms (new host records), *Lepidosaphes gloverii* (Packard, 1869) on *P. roebelenii* (new host record), and *Aspidiotus destructor* Signoret, 1869 on both palms. Among parasitoids, *Aphytis* sp. (Hymenoptera: Aphelinidae) was reared from *C. dictyospermi* and *I. longirostris*, and *Signiphora* sp. (Hymenoptera: Signiphoridae) from *H. cyanophylli* and *I. longirostris*. This is the first record of a species of *Signiphora* Ashmead, 1880 parasitizing *I. longirostris*. The identified armored scales are highly polyphagous and not exclusive to palms, highlighting the need for further research on their diversity and ecology, as well as their natural enemies, in tropical urban environments.

Keywords: Ornamental palms, Diaspididae, Arecaceae, Parasitoids, Predators, Urban Environments.

Armored scale insects (Hemiptera: Coccomorpha: Diaspididae) are recognized as pests of perennial plants on a global scale (Miller & Davidson 2005). This family represents the largest within the superfamily Coccoidea, with over 2600 species in around 422 genera (García Morales et al. 2016; Normark et al. 2019). Considered among the most invasive species globally (Miller & Davidson 2005; Normark et al. 2019), they are commonly found in urban environments, with economically significant infestations documented more frequently in urban areas than in natural settings (Raupp et al. 2010; Beaudoin-Ollivier et al. 2017; Frank & Just 2020). Consequently, urban environments provide an excellent opportunity for studying and predicting the effects of disturbances on scale insect diversity and behavior (Raupp et al. 2010; Frank & Just 2020).

The urban landscape is a complex of habitats developed by humans from natural or agricultural land (Robinson 2005; Held 2020). Within this intricate tapestry, plants emerge as the most conspicuous biological component (Held 2020). Notably, ornamental palms play a prominent role in the urban landscape of tropical areas (MacLeod & Hussein 2017). In Costa Rica, *Dypsis lutescens* (H. Wendel) Beentje & J. Dransf., 1995, and *Phoenix roebelenii* O'Brien, 1889 (Arecaceae) stand out as among the most prevalent palm species in urban environments, the former native to Madagascar and the latter to southeast Asia (Morales 2020). These palms serve as habitats for various insects, including armored scales (Howard 2001a; Beaudoin-Ollivier et al. 2017). Armored scale insects are economically significant in the country, particularly impacting the exportation of agricultural and horticultural products (Evans & Dooley 2013; Malumphy 2015). Armored scale diversity, however, continues to be little explored in Costa Rica.

Globally, more than 100 species of armored scales have been identified on palms, with over 30 affecting *D. lutescens* and *P. roebelenii* (Howard 2001a; 2001b; García Morales et al. 2016), although many of these are not exclusive to palms (Howard 2001a; Faleiro et al. 2016). Several of these species are primary pests of ornamental plants, some are categorized as chronic pests, while others (known as dormant species) are relatively harmless but possess invasive characteristics (Howard 2001a; Miller & Davidson 2005; Frank & Just 2020). All these armored scales could increase their populations in response to environmental changes and perturbations, posing a potential threat to urban landscapes, forests and crops (Ouvrard et al. 2013; Frank & Just 2020). Thus, it is imperative to understand the diversity of armored scales on *D. lutescens* and *P. roebelenii* in the urban landscapes of Costa Rica. Such knowledge is crucial for effective pest management strategies and the preservation of ecosystems

Surveys were conducted within the Greater Metropolitan Area of Costa Rica, including the cities of San José, Heredia, and Alajuela (Fig. 1). All sampled palms were from publicly managed land, and permission from property owners was obtained whenever access to a private yard was required for sampling. In total, 30 palms were randomly selected for sampling from August 2022 to November 2023, with 15 of each palm species. The oldest leaf of each palm was collected and kept in the Entomology Laboratory of the Biology School at the University of Costa Rica, where all the leaflets were observed under a stereomicroscope. Live adult armored scale females found in the samples were collected and placed in ethanol (70%). Slide mounts of adult females were prepared following the procedures described by Watson & Chandler (2000), examined with a transmitted light microscope, and identified by utilizing Watson (2002), Miller & Davidson (2005) and García Morales et al. (2016). Ecological associations were based on Watson (2002) and García Morales et al. (2016). Infested leaf fragments were separated and stored in well-ventilated tubes, and monitored daily for parasitoid emergence (Abell & Van Driesche 2012); the latter were identified to genus with keys found in Hanson & Gauld (1995). In the field, predators observed feeding on scales were meticulously documented, collected, and subsequently identified using keys available in the literature (González 2016; Gordon et al. 2019).

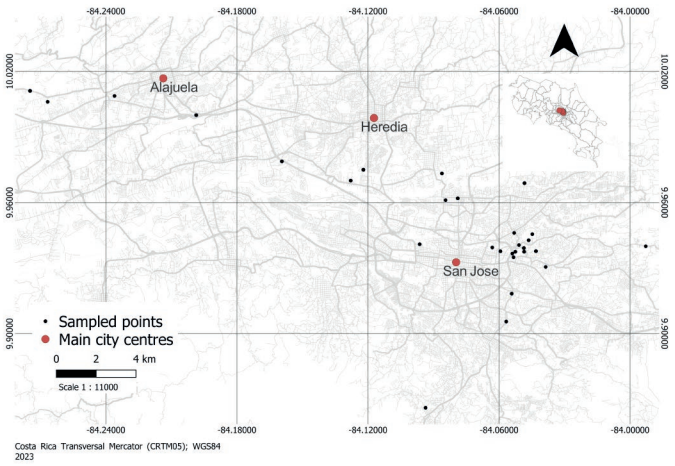

Figure 1. Map of the sampled points in the cities San José, Heredia and Alajuela within the Greater Metropolitan Area of Costa Rica (n = 30).

A total of 12 species of armored scale insects were identified from the 30 palms collected (TaB. 1). Eight were collected on both species of palm: *Ischnaspis longirostris* (Signoret, 1882), *Pseudischnaspis bowreyi* (Cockerell, 1893), *Hemiberlesia cyanophylli* Signoret, 1869, *H. palmae* (Cockerell, 1893), *Pinnaspis apidistrae* (Signoret, 1869), *Lopholeucaspis cockerelli* (Grandpre & Charmoy, 1899), *Chrysomphalus dictyospermi* (Morgan, 1889), and *Aspidiotus destructor* Signoret, 1869. Three species were collected only on *P. roebelenii*: *Selenaspidus articulatus* (Morgan, 1889), *Diaspis boisduvalii* Signoret, 1869, and *Lepidosaphes gloverii* (Packard, 1869). Finally, *Pinnaspis strachani* (Cooley, 1899) was collected only on *D. lutescens*. None of these armored scales are exclusive to palms, i.e. they display polyphagous tendencies, making them potential pests that could pose threats to ornamental landscapes, forests and crops owing to their invasive characteristics (Miller & Davidson 2005; Frank & Just 2020).

Table 1. Armored scale insects associated with *Dypsis lutescens* and *Phoenix roebelenii* palms, and their parasitoids, identified in urban environments in Costa Rica.

Armored scale specie	Palm host	Parasitoids
Ischnaspis longirostris	Dl, Pr	*Aphytis* sp., *Signiphora* sp.*
Pseudischnaspis bowreyi	Dl*, Pr*	-
Selenaspidus articulates	Pr*	-
Hemiberlesia cyanophylli	Dl, Pr*	*Signiphora* sp.
Hemiberlesia palmae	Dl, Pr*	-
Pinnaspis aspidistrae	Dl, Pr*	-
Pinnaspis strachani	Dl	-
Lopholeucaspis cockerelli	Dl, Pr*	-
Diaspis boisduvalii	Pr	-
Chrysomphalus dictyospermi	Dl*, Pr*	*Aphytis* sp.
Lepidosaphes gloverii	Pr*	-
Aspidiotus destructor	Dl, Pr	-

Where Dl = *Dypsis lutescens*, Pr = *Phoenix roebelenii*, * = new host record

Lopholeucaspis cockerelli was previously only reported on intercepted plant material from Costa Rica in Florida by Merrill (1953). In life, the scale cover of *L. cockerelli* adult females is elongate with a longitudinal median ridge, and brown but covered in a thin secretion of white wax (Watson 2002) (Fig. 2a). The body of slide-mounted adult females is more than twice as long as wide, and membranous (Watson 2002) (Fig. 2b). It is also characterized by a sclerotized spine lateral to each antenna, prepygidial margin of thorax and abdomen bordered by a continuous row of duct tubercles as far posteriorly as segments 4 and 5 on the pygidium (Fig. 2b), and 11-18 macroducts on each side of the pygidium (Watson 2002) (Fig. 2c). Similarly, *P. bowreyi* was previously only reported on *Carya*, *Persea*, *Prunus*, and *Rosa* on intercepted plant material from Costa Rica from 1932 to 1951 (Miller et al. 1984). In life,

Figure 2. *Lopholeucaspis cockerelli*: (A) scale cover of adult female, (B) slide-mounted adult female where the arrow indicates continuous row of duct tubercles as far posteriorly as segments 4 and 5 on pygidium and (C) adult female pygidium where the arrow indicates 11 macroducts on each side of the pygidium. *Pseudischnaspis bowreyi*: (d) scale cover of adult female, (E) slide-mounted adult female and (F) adult female pygidium where the arrow indicates 6 macroduct orifices in a row beginning between median margin of lobe 3 and interlobular paraphysis in the second space.

the scale cover of adult females is subcircular to elongate oval, blackish but with a purplish-brown or bluish grey tinge; the exuviae are terminal or subapical, brownish black, the first instar exuviae often forming a crater in the center of the more convex second instar exuviae (Watson 2002) (Fig. 2d); the body and pygidial shape are morphologically diverse (Miller et al. 1984). The body of slide-mounted adult females is pyriform to elongate oval and more than 2x as long as wide, similar to Watson (2002) (Fig. 2e). The pygidium has an area anterior to lobe 3 with 4-5 lobelike projections, the median lobes are separated by a space 0.3-0.7(0.5)x the width of the median lobe, with 6 macroduct orifices in a row beginning between the medial margin of lobe 3 (Miller et al. 1984) (Fig. 2f).

The armored scale insect most frequently observed was *I. longirostris* which was present in 100% of the samples from both palm species. *H. cyanophylli* was the second most frequent armored scale, present in 87% and 73% of the samples from *P. roebelenii* and *D. lutescens*, respectively. *Aphytis* sp. (Hymenoptera: Aphelinidae) and two unidentified species of *Signiphora* Ashmead, 1880 (Hymenoptera: Signiphoridae) were reared from *I. longirostris* (Tab. 1). This represents the first documentation of *Signiphora* parasitizing *I. longirostris*; previously, only *A. chrysomphali* and *Coccophagus caridei* (Brèthes, 1918) (Hymenoptera: Aphelinidae) have been noted as parasitoids of this armored scale species (García Morales et al. 2016). Another species of *Signiphora* was reared from *H. cyanophylli* (Tab. 1). A total of six species of *Signiphora* have been reported associated with *H. cyanophylli* (García Morales et al. 2016). In addition, *Aphytis* sp. was reared from *C. dictyospermi* (Tab. 1); 15 species of *Aphytis* have been reported parasitizing *C. dictyospermi* (García Morales et al. 2016). Wasps of the genus *Signiphora* are primary parasitoids or hyperparasitoids associated mostly with scale insects, mealybugs and whiteflies (Woolley & Hanson 2006; Woolley & Dal Molin 2017) while wasps of the genus *Aphytis* Howard, 1900 are primary ectoparasitoids of Diaspididae (Myartseva et al. 2010). The predators *Azya* sp., three different species of *Pentilia* Mulsant, 1850 and two other unidentified Coccinellidae were collected preying on the armored scale insects, along with the larva of an unidentified species of Chrysopidae. Species of Coccinellidae and Chrysopidae are some of the main natural enemies found preying on scale insects in urban environments (Wilson & Frank 2023; Wilson et al. 2023).

In conclusion, the armored scales identified in this study are quite polyphagous and are not exclusive to palms. Given their polyphagous nature and the potential for them to become pests (Miller & Davidson 2005), further research on the diversity and ecology of armored scale insects and their natural enemies in urban environments in Costa Rica is imperative. A comprehensive understanding of the interactions between these armored scales, their natural enemies, and the surrounding environment is pivotal. This knowledge provides a foundation for the formulation and implementation of well-informed integrated pest management strategies.

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Authors' Contributions

MSG: Conceptualization, Formal Analysis, Methodology, Investigation, Writing - original draft; Writing - review & editing. PH: Conceptualization, Formal Analysis, Methodology, Writing - review & editing, Validation, Resources.

Data Availability

The dataset and additional information generated in this study are available from the corresponding author.

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