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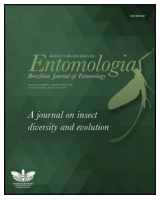

A new threat to Ecuadorian flora: first report of the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green, 1908) (Hemiptera: Pseudococcidae) and its potential biological control agent

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ABSTRACT

The presence of the pink hibiscus mealybug (PHM), *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) is reported for the first time in urban trees in Guayaquil (2022) and Portoviejo (2023), Ecuador. PHM was found in more than 55 plant species, including export crops. Among the most affected species in this study are plants from the families Anacardiaceae, Annonaceae, Fabaceae, Heliconiaceae, Malvaceae, Rhizophoraceae, Rubiaceae, Verbenaceae and Zingiberaceae. Additionally, the wasp *Anagyrus kamali* Moursi (Hymenoptera: Encyrtidae) was detected parasitizing *M. hirsutus* in several locations, including the cantons of Manta and Portoviejo, in the province of Manabí, and in the Samborondón canton, in the province of Guayas. This finding opens the possibility of implementing effective biological control strategies, reducing dependence on insecticides and protecting biodiversity. Environmental education is recommended to promote sustainable agricultural practices and integrated pest management.

Introduction

In Ecuador, since 2021, in the cantons of Guayaquil and Samborondón, province of Guayas, and in the cantons of Portoviejo and Manta, province of Manabí, population outbreaks of a new pest not previously recorded in the region have been observed, attacking urban trees and other plant species, including guachapeli, *Albizia guachapele* (Kunth) Dugand, saman, *Samanea saman* (Jacq.) Merr. (Fabaceae), hibiscus, *Hibiscus* spp., cacao, *Theobroma cacao* L. (Malvaceae), coffee, *Coffea arabica* L. (Rubiaceae), soursop, *Annona muricata* L. (Annonaceae), lobster-claws, *Heliconia* spp. (Heliconiaceae), red ginger, *Alpinia purpurata* (Vieill.) K.Schum. (Zingiberaceae), lantana, *Lantana camara* L. (Verbenaceae), red mangrove, *Rhizophora mangle* L. (Rhizophoraceae), mango, *Mangifera indica* L., and *Spondias* spp. (Anacardiaceae). The mealybug causing outbreaks in the region were identified as the pink hibiscus mealybug (PHM), *Maconellicoccus hirsutus* (Green, 1908) (Hemiptera: Pseudococcidae). Furthermore, a primary parasitoid was also recovered from the mealybug samples and identified as *Anagyrus kamali* Moursi, 1948 (Hymenoptera: Encyrtidae).

Originally from Southeast Asia, the PHM has rapidly spread throughout tropical and subtropical regions of the world, including Asia, Africa, Oceania, and the Americas (Williams, 1986, 1996; Meyerdirk et al., 2001; Hoy et al., 2002). Since its first record in the Western Hemisphere in Hawaii in the 1980s, this pest has rapidly colonized the Caribbean, Central America, the United States, and South America, taking advantage of favorable climatic conditions for its development (Cermeli et al., 2002; Isiordia-Aquino et al., 2012; Kondo et al., 2012; Culik et al., 2013; Mexico, 2016).

The PHM is highly polyphagous, as it can attack 330 species from 87 families (García Morales et al., 2016; Harman, 2022). This pest affects a wide range of crops, including cotton, cacao, coffee, coconut, citrus, *Ficus* spp., soursop, mango, papaya, grapes, cassava, various vegetables, forest trees, wild plants, and numerous ornamental species such as hibiscus, feeding on leaves, stems, fruits, and roots (Meyerdirk et al., 2001; Chong et al., 2008; Mexico, 2014, 2016; Torres de la Cruz et al., 2019; Watson, 2021; Harman, 2022). Its ability to adapt to different plant species makes it a difficult pest to control in house gardens and backyards, with the most affected ornamental plants being *Hibiscus* spp. (Kondo et al., 2012).

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The PHM feeds on plant sap, injecting toxins that cause severe deformations in leaves, stems, flowers, and fruits; these deformations, together with the production of honeydew and the development of sooty mold, prevent photosynthesis and affect plant growth, and can even cause dieback of the affected plants (Mexico, 2016; Harman, 2022). The honeydew produced by the PHM attracts ants, which provide protection to the mealybug, exacerbating infestation and necessitating effective control measures (Harman, 2022). With a short life cycle of 23 to 30 days from egg to adult, the PHM can complete up to 15 generations per year under optimal conditions (Meyerdirk et al., 2001; Chong et al., 2008). Females lay between 150 and 600 eggs within an ovisac, with eggs hatching in approximately one week (Chong et al., 2008). This rapid reproduction explains their ability to form large populations in a short time.

The PHM disperses over both short and long distances. At short distances, dispersal occurs mainly by wind, water, animals (such as ants, birds and livestock) and contaminated agricultural tools (Harman, 2022). Strong winds, such as those associated with tropical cyclones, can transport the mealybugs over considerable distances (Kairo et al., 2000; Harman, 2022). Primarily, long-distance dispersal of this insect pest is driven by human activities, such as the transportation of infested plant material (fruits, flowers, plants) through various means, including international trade (Kairo et al., 2000; Martínez, 2007; European Union, 2014; Mexico, 2014, 2016; Harman, 2022).

Twenty-five insect genera across nine families have been identified as natural enemies that control the PHM (García Morales et al., 2016). Notably, three species have demonstrated exceptional efficacy in large-scale biological control programs against PHM. In warm climates, such as the Caribbean islands, the predatory beetle *Cryptolaemus montrouzieri* Mulsant, 1850 (Coleoptera: Coccinellidae) and the hymenopteran parasitoids *A. kamali* and *Gyranusoidea indica* Shafee, Alam & Agarwal, 1975 (Hymenoptera: Encyrtidae) effectively suppress mealybug populations (Harman, 2022). By initially reducing mealybug outbreaks, *C. montrouzieri* creates conditions that allow parasitoids to more effectively control the remaining populations (Chong et al., 2015; Harman, 2022).

In Brazil, numerous natural enemies have been recorded associated with *M. hirsutus*, including the parasitoid *G. indica* and the predators *Cycloneda sanguinea* (L., 1763), *C. montrouzieri*, *Chilocorus nigritus* (Fabricius, 1798), *Exoplectra* sp., *Harmonia axyridis* (Pallas, 1773), *Tenuisvalvae notata* (Mulsant, 1850) (Coleoptera: Coccinellidae) and *Ceraeochrysa* sp. (Neuroptera: Chrysopidae) (Peronti et al., 2016). On the other hand, in Colombia, Montes-Rodríguez et al. (2024) reported two new natural enemies of *M. hirsutus*, i.e., *Allotropa* cf. *citri* Muesebeck, 1954 (Hymenoptera: Platygastridae) and *Leucopina nyiaybsa* Gaimari & Montes, 2024 (Diptera: Chamaemyiidae). These authors also reported on the distribution of the parasitoids *A. kamali* and *G. indica* which together with *C. montrouzieri* and *L. nyiaybsa* are important natural enemies of PHM (Montes-Rodríguez et al., 2024). The objective of this study is to report for the first time the presence of the pink hibiscus mealybug, *M. hirsutus* and one of its main parasitoids, the wasp *A. kamali* in Ecuador.

Materials and methods

Study area

The present study was carried out by collecting shoots from affected plants at the following sites: Guayas Province: Guayaquil Botanical Garden (79°54′32″W, 02°04′47″S,11 m a.s.l.); Samborondón Historical Park, (79°52′12″W, 2°08′43″S, 7 m a.s.l.), Espíritu Santo University (UEES) (2°07′57″S, 79°52′06″W, 5 m a.s.l.); Manabí Province: Portoviejo, Ciudadelas California (01°03′36″S, 80°28′17″W, 37 m a.s.l.), Manta, Los Tamarindos (01°03′41″S, 80°28′36″W, 26 m a.s.l.); and Tarqui parish at the mouth of the Manta River (00°57′00″S, 80°42′29″W, 6 m a.s.l.). The climate of the study area is characterized by an average annual rainfall of 1030 mm, 85% relative humidity and 26°C temperature, with a defined wet season from January to April and a dry season from May to December. In all the urban green areas studied there is presence of exotic and native plants from the families Bignoniaceae, Burseraceae, Fabaceae, Malvaceae, and Rubiaceae (Molina-Moreira et al., 2015, 2023) that are affected by the PHM. The map of the sampled area was prepared using ARCGIS, version 10.4 (Fig. 1).

Identification of PHM

Under the MAAE-DBI-CM-2022-0234 permit granted by the Ministry of the Environment of Ecuador, the first author collected deformed leaves and shoots or "bunchy top", leaves and fruits containing mealybugs from saman trees at the Universidad de Especialidades Espíritu Santo (UEES), Samborondón, Guayas. With the help of an Olympus stereomicroscope, version SZ5, mature females without eggs were chosen and placed in a vial with 70% alcohol. The samples were entered with the Work Order: 09-2023-3564 on August 23, 2023, to the AGROCALIDAD Entomology Laboratory in Guayaquil with the field code UEES1S for processing, staining, and slide-mounting preparation method of AGROCALIDAD (No. PEE/E/03) and Kondo and Watson (2022). Samples rest in the entomology museum of AGROCALIDAD, in Tumbaco, Quito. Voucher specimens preserved in 70% alcohol are deposited in the UEES laboratory with the code number E09-24-0200.

The slide-mounted specimens were identified using the interactive keys, descriptions, and diagnoses of SENASICA (Mexico, 2018), Miller et al. (2014), Williams (2004) and Harman (2022).

Identification of host plants of PHM

Host plants were identified *in situ* using the Pl@ntnet mobile application (Goëau et al., 2013), photographs of flowers, fruits, stems and/or leaves were taken, and compared with descriptions and bibliographies of Molina-Moreira et al. (2015, 2023), MAE (2014), and Palacios (2016a, 2016b). The scientific names of the plants were verified using the database "The Missouri Botanical Gardens VAT – Vascular Tropicos" (Tropicos, 2025) and the International Plant Names Index (IPNI, 2025).

Determination of infestation levels caused by PHM

The following scale was used to determine the levels of infestation of this pest: Null: 0; Low: > 1-10; Medium: >10-20; High: > 20 on a sample unit that consisted of cutting a 5 cm long branch or terminal shoot at each cardinal point of the plant (Mexico, 2009). The coordinates of each point were taken using a GPS.

Collection and identification of natural enemies of PHM

Natural enemies associated with PHM were recorded from samples taken at random from ten saman shoots of approximately 5 cm length. Observations were made with an Olympus stereomicroscope version SZ5. Adult female and male wasps emerged from parasitized adult females of PHM found in samples collected at different locations and dates: on November 26, 2023, in Portoviejo (Ciudadelas California and Los Tamarindos) on *Albizia guachapele* and *Hibiscus* spp.; and on terminal shoots of saman trees in Manta on December 18, 2023, and at UEES, Samborondón, Guayas on February 1, 2024. The wasps that

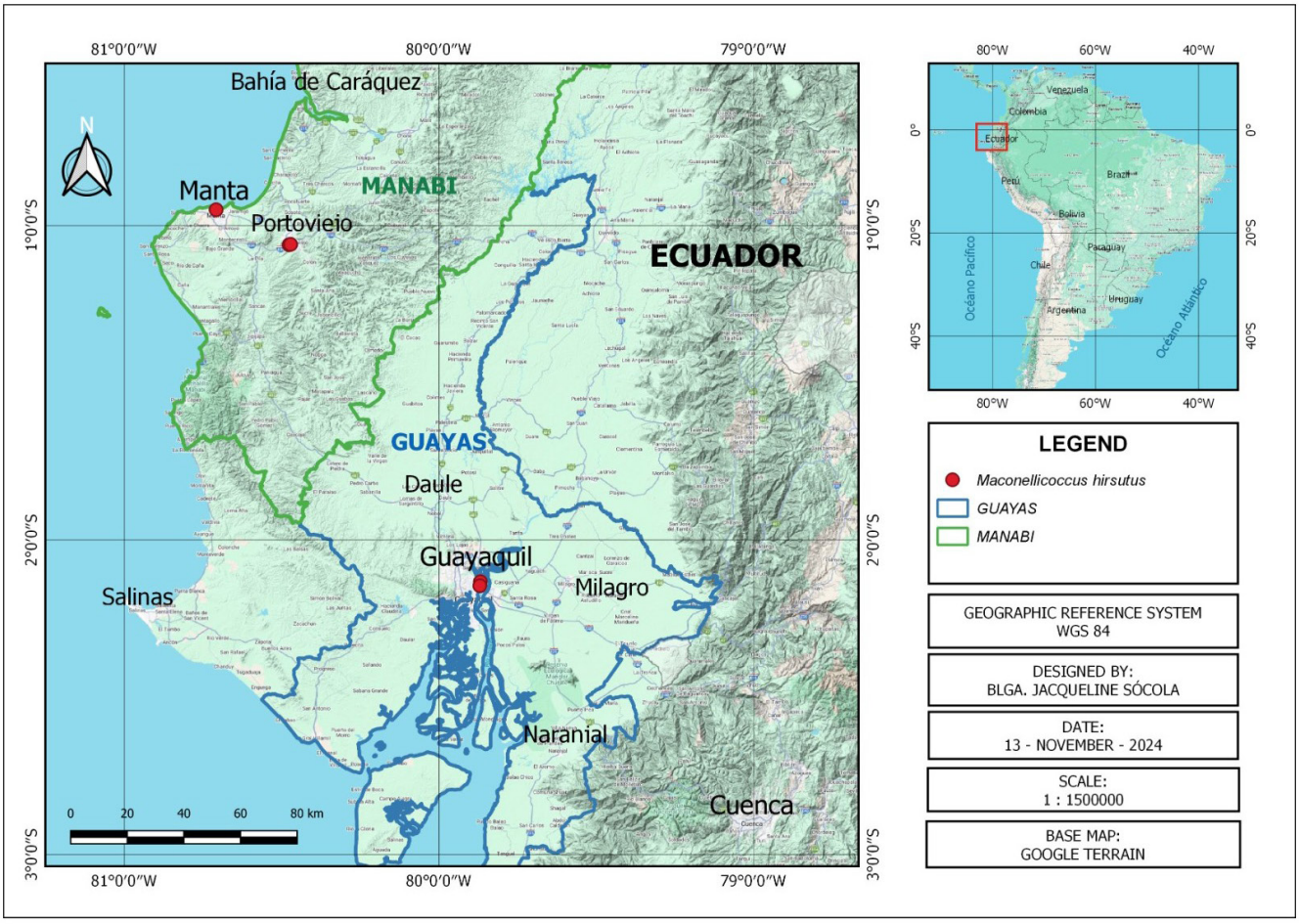

Figure 1. Sampling sites in the provinces of Manabí and Guayas, Ecuador.

emerged were quickly slide-mounted in CMC-10 and photographed with the aid of a Better Scientific microscope in the UEES laboratory attached to a NIKON SMZ745T-Mshot-MS60 camera. Identification of the parasitoids was based on the comparison of their morphological characteristics with those previously described in the literature (Noyes, 2003; Evans et al., 2012; Montes-Rodríguez, 2012; Rameshkumar et al., 2013; Ramírez-Guillermo et al., 2020). On January 24, 2024, twenty pairs of parasitoids were entered into the AGROCALIDAD laboratory in Guayaquil with work order 09-2024-0193, field code UEES2 for mounting and taxonomic verification by Marjorie Plúas who confirmed the taxonomic identification of *A. kamali*. The methods used by Arias de López et al. (2024) were used for the collection and identification of predators of PHM in this study.

Results and discussion

Identification of Maconellicoccus hirsutus

The identification of *M. hirsutus* was confirmed on September 6 by report LR-GUAYAS- E-I23-2821, issued by Agrocalidad-Guayaquil. The identification was corroborated by T. Kondo, revealing the presence of this quarantine pest for the first time in Ecuador, in the provinces of Guayas and Manabí. The morphology of slide-mounted specimens agrees with those provided by Miller (1999), and Williams (1986, 1996, 2004). Figs. 2A, 2B and 2C show the typical external morphological characteristics of the live specimens and their damage.

Host plants of M. hirsutus

Saman trees in Guayas province were the most susceptible due to their small leaflets (Fig. 3A), showing bunchy top damage symptoms (Fig. 3B), and forming large white colonies on branches, trunks, and cracks in the trees (Fig. 3C). These observations coincide with those reported in scientific literature (e.g., Meyerdirk et al., 2001; Mexico, 2016). In Fig. 3D is shown a tree of *A. guachapele*, and in Fig. 3E are shown plants of *Hibiscus rosa-sinensis* L. (Malvaceae), which have died due to the strong attack of PHM. In the Historical Park, the red mangrove, *Rhizophora mangle* (not illustrated), *Hibiscus tiliaceus* L. (Malvaceae) (not illustrated), which is a facultative mangrove, and the fruits of *Cassia fistula* L. (Fabaceae) (Fig. 3F) were highly infested, while button mangrove, *Conocarpus erectus* L. (Combretaceae) (not illustrated), showed medium level infestation. No infestation was observed in *Calathea lutea* (Aubl.) Schult. (Marantaceae), a common plant in the study area. The main host plants and the level of infestation are presented in Table 1.

Natural enemies of M. hirsutus

During observations of infested shoots of the main host plants in Guayaquil, we only recorded generalist predatory natural enemies such as *Cereaochrysa* sp. (Neuroptera: Chrysopidae), and the anthocorid bug *Cardiastethus* sp. (Hemiptera: Anthocoridae). These predators have been recently reported as natural enemies of the invasive fluted

Figure 2. Pink hibiscus mealybug, *M. hirsutus*. **A.** Adult female, adult male (the winged specimen) and nymphs. **B.** Adult females with ovisacs. **C.** Nymphs and an ovisac showing eggs in its interior. Photos: M. Arias de López.

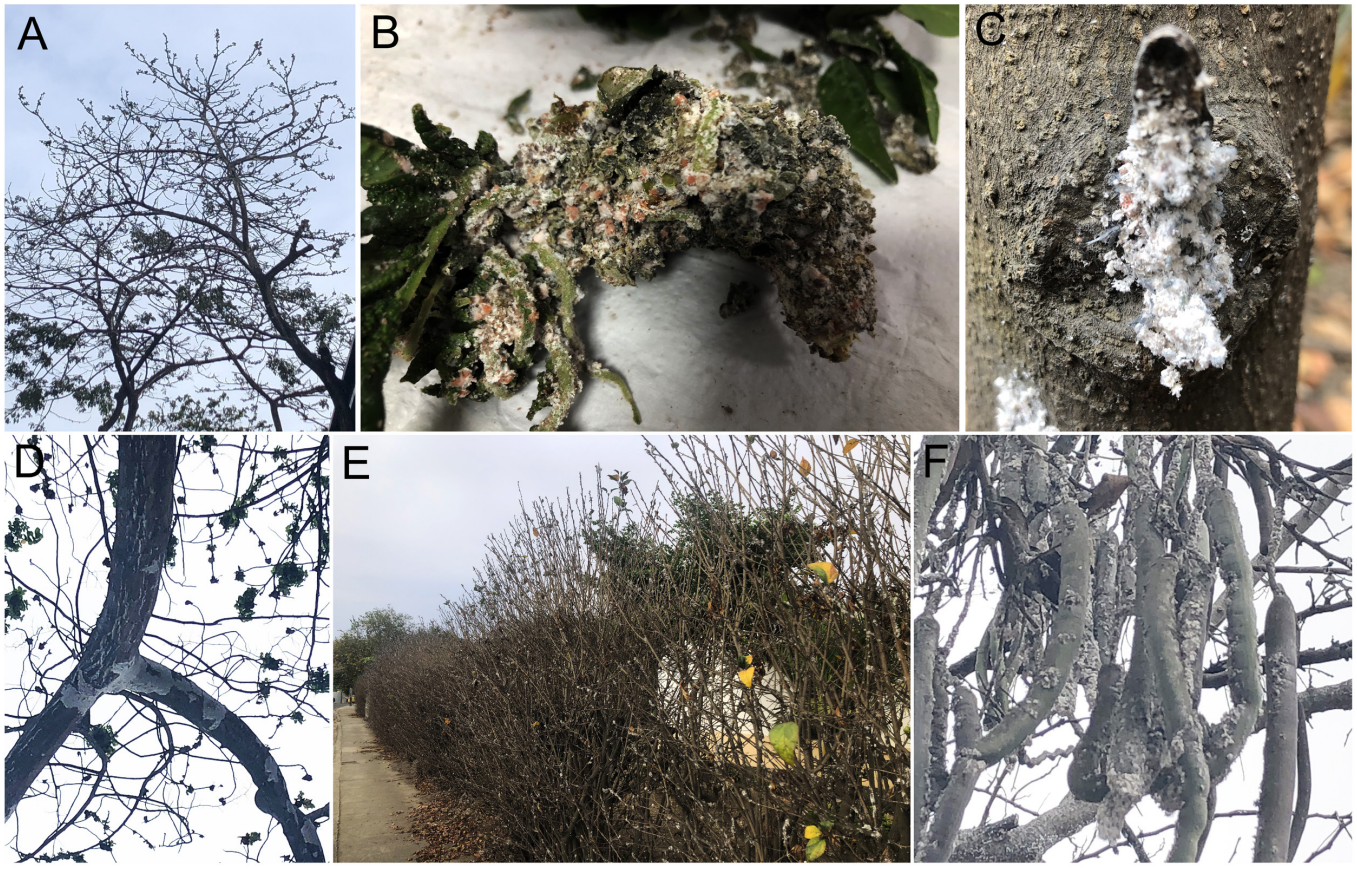

Figure 3. Host plants of PHM in the study area. **A.** Heavily infested *Samanea saman*. **B.** Deformed shoot (bunchy top) of saman tree. **C.** Stem with large number of ovisacs. **D.** *Albizia guachapele* showing branches with typical bunchy top symptoms. **E.** Heavily infested *Hibiscus rosa-sinensis* plants showing dieback. **F.** Heavily infested fruits of *Cassia fistula*. Photos: M. Arias de López.

scales *Crypticerya* spp. and *Icerya purchasi* (Herrera et al., 2021; Arias de López et al., 2022, 2024) in the same study area. *Cereaochrysa* sp. have also been mentioned by Peronti et al. (2016) as a predator of PHM in Brazil, but it is unknown whether the species reported in Brazil is conspecific with the species found in Ecuador. Although the coccinellid *C. montrouzieri* is likely present in Ecuador, based on its occurrence in neighboring countries such as Colombia (Montes-Rodríguez et al., 2024) and Peru (González, 2015), this predator was not observed preying on PHM in Manabí and Guayas.

According to the results of the present study (Table 2), the parasitoid wasp *A. kamali* is the main natural enemy of *M. hirsutus* in Ecuador. So far, this is the only species of parasitoid found attacking the PHM in Ecuador. This species was found parasitizing PHM on *A. guachapele* and *Hibiscus* spp. in November in the city of Portoviejo, and on saman in the city of Manta in December, and at the campus of the Universidad Espíritu Santo (UEES), Samborondón, Guayas in February 2024. *Anagyrus kamali* as well as many other parasitoids can be recognized because they mummify the mealybugs (Fig. 4A) and produce an exit hole when the wasps leave their insect host (Fig. 4B). The adult female of *A. kamali* in lateral view is shown in Fig. 4C. It is very likely that this parasitoid wasp entered Ecuador together with the PHM. The results obtained confirm the presence of this species in Ecuador. A total of 1899 parasitoids were

Table 1.
Host plants of *M. hirsutus* and infestation levels recorded in Guayaquil, Ecuador.

Host plant species		Infestation levels		
Family	Species	High	Medium	Low
Acanthaceae	*Pachystachys lutea* Nees	X		
Anacardiaceae	*Mangifera indica* L.		X	X
	Spondias mombin L.	X		
	Spondias purpurea L.	X		
Annonaceae	*Annona glabra* L.			X
	Annona muricata L.	X		
	Annona squamosa L.		X	
Apocynaceae	*Nerium oleander* L.		X	
	Plumeria rubra L.			X
Araceae	*Philodendron hederaceum* (Jacq.) Schott	X		
	Syngonium podophyllum Schott.	X		
Arecaceae	*Dypsis lutescens* (H. Wendl.) Beentje & J. Dransf.	X		
Asteraceae	*Cyanthillium cinereum* (L.) H. Rob.	X		
Bignoniaceae	*Crescentia cujete* L.		X	
	Jacaranda mimosifolia D. Don	X		
	Handroanthus chrysanthus (Jacq.) S.O. Grose	X		
	Tabebuia rosea (Bertol.) DC.		X	
Chrysobalanaceae	*Couepia subcordata* Benth. ex Hook. f.	X		
Combretaceae	*Conocarpus erectus* L.		X	
Cordiaceae	*Cordia lutea* Lam.		X	
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn		X	
Fabaceae	*Albizia guachapele* (Kunth) Dugand	X		
	Cassia fistula L.	X		
	Cassia angustifolia Vahl		X	
	Inga edulis Mart.		X	
	Laburnum anagyroides Medik.	X		
	Libidibia glabrata (Kunth) C. Cast. & G.P. Lewis	X		
	Samanea saman (Jacq.) Merr.	X		
	Zygia latifolia (L.) Fawc. & Rendle	X		
Heliconiaceae	*Heliconia psittacorum* L. f.		X	
Malvaceae	*Guazuma ulmifolia* Lam.	X		
	Hibiscus rosa-sinensis L.	X		
	Talipariti tiliaceum (L.) Fryxell	X		
	Theobroma cacao L.	X		
Moraceae	*Artocarpus heterophyllus* Lam.	X		
Musaceae	*Musa* × *paradisiaca* L.	X		
Myrtaceae	*Callistemon citrinus* (Curtis) Skeels		X	
	Myrtus communis L.		X	
	Psidium guajava L.		X	
Nyctaginaceae	*Bougainvillea spectabilis* Willd.	X		
Passifloraceae	*Turnera ulmifolia* L.		X	

Table 1.
Continued...

Host plant species		Infestation levels		
Family	Species	High	Medium	Low
Piperaceae	*Piper aduncum* L.	X		
Rhizophoraceae	*Rhizophora harrisonii* Leechm.			X
	Rhizophora mangle L.	X		
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl.	X		
Rubiaceae	*Alseis eggersii* Standl.	X		
	Coffea arabica L.	X		
	Ixora coccinea L.		X	
Rutaceae	*Citrus x sinensis* (L.) Osbeck		X	
Sapotaceae	*Pouteria sapota* (Jacq.) H.E. Moore & Stearn	X		
Solanaceae	*Acnistus arborescens* (L.) Schltdl.	X		
Verbenaceae	*Duranta erecta* L.		X	
	Lantana camara L.		X	
Zingiberaceae	*Alpinia purpurata* (Vieill.) K.Schum.	X		

Table 2.
Number of insect specimens of *Anagyrus kamali* (Hymenoptera: Encyrtidae) found parasitizing *M. hirsutus* by locality and plant host, in samples collected between 2023-2024.

Locality	Associated plants	Anagyrus kamali		Number of specimens
		Females	Males	
Portoviejo	*Albizia guachapele*	205	185	390
	Hibiscus rosa-sinensis	68	102	170
Manta	*Samanea saman*	465	806	1271
Samborondón (UEES)	*Samanea saman*	23	7	30
Samborondón (Parque Histórico)	*Rhizophora mangle*	18	20	38
	Total			1899

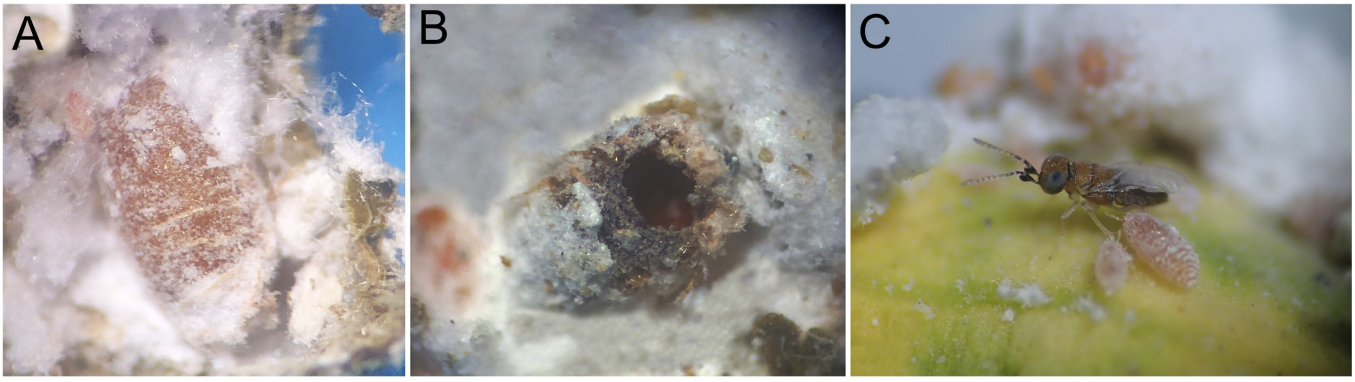

Figure 4. Pink hibiscus mealybug, *M. hirsutus* parasitized by *A. kamali*. **A.** Parasitized PHM adult female. **B.** Mealybug with an exit hole made by *A. kamali*. **C.** Adult female of *A. kamali*. Photos: A and B by M. Arias de López; C by T. Kondo.

recovered from mealybug mummies in the present study indicating that this species is found in abundance and is acting as an important natural enemy of PHM. In Table 2 is shown in detail the number of specimens collected during the period 2023-2024 by location and host. To date, no other parasitoid species indicated by different authors have been found (e.g., García-Valente et al., 2009; García-Álvarez, 2011; Evans et al., 2012; Montes-Rodríguez, 2012; Rameshkumar et al., 2013; Peronti et al., 2016; Pedraza-Ramón et al., 2018; Soler et al., 2021; Harman, 2022).

Due to the presence of the PHM, an invasive insect of quarantine category (Ecuador, 2019), it is necessary to promote its surveillance in all places where there are crops of economic importance, recommending the release of natural enemies. Collecting, breeding and releasing *A. kamali*, the main natural enemy in areas where it is present, to reduce its populations and damage has shown an efficiency of up to 96.5% in places of high infestation (García-Valente et al., 2009). Meyerdirk et al. (2001) recommend collecting *A. kamali* in entomological sleeves and releasing them in places where the host plants show high infestations, for their multiplication, dispersion and to reduce the damage caused by the PHM. Nymphs and adults of the PHM possess a waxy coating, and the eggs are found inside a waxy ovisac that protects them from the application of insecticides (Alemán et al., 2005; Ramos-Cordero et al., 2018; Surwase et al., 2020; Harman, 2022). On the other hand, chemical control is not efficient and causes the mortality of beneficial insects (Juárez-Maya, 2021), frequently causing the resurgence of the PHM at levels that cannot be managed. Public and private institutions must join forces to confront this entomological problem of quarantine importance that is causing damage to urban trees and putting the production and export of agricultural products at risk. The creation of insectaries to produce natural enemies is recommended, which has been successful in different places around the world (Meyerdirk et al., 2001; Roltsch, 2010) where the PHM is present.

Conclusions

This study confirms the first official detection of the pink hibiscus mealybug (PHM), *M. hirsutus* in Ecuador. Several host plants, particularly *S. saman*, *A. guachapele*, and species of *Hibiscus*, exhibited severe infestations, consistent with patterns reported in other countries. Among the natural enemies recorded, the parasitoid wasp *A. kamali* was the only specialized biological control agent found attacking PHM in the field and appears to have established in Ecuador. Its abundance and widespread presence suggest it plays a key role in managing PHM populations. In contrast, only generalist predators, namely *Cereaochrysa* sp. and *Cardiastethus* sp. were observed. No other predators were found, including *C. montrouzieri*. Given the invasive nature of PHM, its resistance to chemical control, and its impact on economically and ecologically important plants, it is essential to strengthen surveillance and promote integrated biological control strategies. The development of insectaries for mass-rearing and release of *A. kamali* is strongly recommended as a sustainable management approach.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

MAL data curation, formal analysis, investigation, methodology, project administration, resources, supervision, visualization, writing - original draft, writing - review & editing. NMM conceptualization, funding acquisition, investigation, methodology, project administration, resources, supervision, writing - original draft, writing - review & editing. TK conceptualization, data curation, investigation, methodology, supervision, validation, visualization, writing - review & editing.

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