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Orquídeas epífitas de ornato en Puerto Vallarta, Jalisco

Ornamental epiphytic orchids in Puerto Vallarta, Jalisco

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ABSTRACT

Epiphytic orchids have been widely used since pre-Hispanic times as ornamental plants. The epiphytic orchid use in religious ceremonies and popular festivities has been widely documented; however, few studies have shown their ornamental use in houses and commercial establishments. This work aimed to evaluate the richness and abundance of epiphytic orchids for ornamental use in Puerto Vallarta, México. A census was carried out within the municipality, including 24 houses and two restaurants with orchids in their playgrounds, gardens, terraces, and garages. Measured parameters included identity, abundance, flower color, and distribution. A total of 521 orchids from 16 genera and 33 species (16 endemic, nine native, and eight exotic) were recorded. On average, the houses exhibited greater richness in endemic orchids, with no apparent preferences for any flower color. Based on frequency and abundance, 12 species were classified as dominant, eight as occasional, and 13 as rare. The exotic species *Phalaenopsis* sp. was the most abundant, while the endemic species *Trichocentrum natalieae* and *Myrmecophila galeottiana* were the most frequent. Changes in land use due to agricultural activities and low population density are potential threats to orchid populations and habitats.

KEY WORDS: *Orchidaceae*, native, endemic, exotic, richness, abundance, ornamental plants.

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RESUMEN

Las orquídeas epífitas han sido ampliamente utilizadas desde la época prehispánica como plantas de ornato. El uso de las orquídeas epífitas en ceremonias religiosas y festividades populares se ha documentado ampliamente; siendo escasos los estudios que muestren su uso ornamental en casas y comercios. El objetivo de este trabajo fue evaluar la riqueza y abundancia de las orquídeas epífitas que se usan de ornato en Puerto Vallarta. Se realizaron recorridos dentro del municipio, censando 24 casas y dos comercios que tenían orquídeas en sus patios, jardines, terrazas y cocheras frontales. Se obtuvo la identidad, abundancia, color de flor y distribución. Se registraron 521 orquídeas de 16 géneros y 33 especies (16 endémicas, nueve nativas y ocho exóticas). En promedio, las casas tienen una mayor riqueza de orquídeas endémicas, sin preferencia por algún color de flor. De acuerdo con su frecuencia y abundancia, 12 especies fueron dominantes, ocho ocasionales y 13 raras. La especie exótica *Phalaenopsis* sp. fue la más abundante, las especies endémicas *Trichocentrum natalieae* y *Myrmecophyla galeottiana* fueron las más frecuentes. El cambio de uso de suelo por actividades agrícolas y la baja densidad poblacional son los factores que potencialmente amenazan a las poblaciones o hábitat de las orquídeas.

PALABRAS CLAVE: *Orchidaceae,* nativa, endémica, exótica, riqueza, abundancia, plantas de ornato

Introduction

Due to their attractiveness, epiphytic orchids are a plant group that has been used since pre-Hispanic times (Solano-Gómez *et al.,* 2010). Vanilla (*Vanilla planifolia*) was the first orchid species to be used by the Totonac settlements in the north of Veracruz state, which was already the object of tribute to the Aztecs in 1447, but it is believed that its use dates back to the 1400s (Hágsater *et al.,* 2005; Aguirre, 2021), being the first orchid referred to in the west and described as late as 1808 (Aguirre, 2021). Another species widely used since pre-Hispanic times is *Laelia autumnalis*, or flor de muerto, from which the mucilage (glue or paste) contained in the pseudobulbs was extracted and used to fix pigments and glue the feathers that adorned the clothing (plumes, royal mantles, and capes), arms, and legs, as well as several accessories (ceremonial shields, and fans) of the Aztec emperors and their servants (Beltrán-Rodríguez *et al.,* 2012; Cox-Tamay *et al.,* 2016; Hágsater *et al.,* 2005; Emeterio-Lara *et al.,* 2016). Currently, in some regions of Mexico, indigenous and mestizo communities collect different epiphytic orchids for self-supply and commercialization, especially those with ornamental value or those used in religious ceremonies

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and popular festivities (Beltrán-Rodríguez *et al.,* 2012). The inflorescences of wild populations are harvested for the arrangement of altars, atriums, chapels, tombs, and ramadas, among others, which are used both in houses and in pantheons as bouquets, baskets, vases, wreaths, or garlands (Beltrán-Rodríguez *et al.,* 2012; Solano-Gómez *et al.,* 2010). Most of the literature has focused on the ornamental use of epiphytic orchids in ceremonies and festivities (Haeckel, 2008; Solano-Gómez *et al.,* 2010), with few studies documenting their ornamental use in house gardens and orchards; that is, where they serve as more permanent ornamental features (Gamboa, 2011).

From an environmental perspective, *Orchidaceae* is one of the most threatened families, facing factors that threaten the natural population permanence (Hágsater *et al.,* 2005, Solano 2021). The factors that threaten orchid populations or habitats on a national scale are mainly divided into intrinsic and extrinsic. Intrinsic factors are related to the dynamics and population size of orchid species, such as life history traits, distribution area, population structure, reproductive system, fecundity, recruitment rate, and seed viability, among others (Sarmiento & Romero, 2000; Solano, 2021). Extrinsic factors are those related to anthropogenic activities, including fragmentation and deforestation of their habitats due to land use change, forest fires, effects related to climate change, massive extraction, and illicit national and international trade of wild specimens given their high value for horticulturists, collectors and the general public (Cox-Tamay *et al.,* 2016; Castillo-Pérez *et al.,* 2019; Hinsley *et al.,* 2018; Solano 2021). Currently, orchids are the second most threatened family in Mexico in terms of illegal extraction and trafficking of species, including protected natural areas (Castillo-Pérez *et al.,* 2018). Mexican laws sanction the illegal trade of orchid specimens, but this practice is allowed at a local level as part of the uses, traditional customs and livelihoods of indigenous and mestizo communities, categorized as extraction and sale of non-timber forest resources (Cruz *et al.,* 2015; Emeterio-Lara *et al.,* 2016; Jiménez-López *et al.,* 2019a, b; Espejo-Cruz *et al.,* 2023). Orchid trade in traditional markets is based on specimen extraction from the wild and therefore does not comply with current regulations and permits from the environmental authority, resulting in illegal activity (Jiménez-López *et al.,* 2019a). Recently, the sale of Mexican orchids has been identified in online trading platforms (e-commerce), a trade practice that promotes environmental crimes since sellers do not have any records or permits from the environmental authorities (Espejo-Cruz *et al.,* 2023). As is the case throughout the country, in Jalisco, endemic and native orchids face factors that put the permanence of their wild populations at risk (Vargas-Ponce *et al.,* 2017).

Orchidaceae is considered the largest and most specialized family of angiosperms (Dressler, 2005; Hásgsater *et al.,* 2005; Castillo-Pérez *et al.,* 2018). Emerging 112 million years ago (Givish *et al.,* 2015), the family includes approximately 800 genera and more than 30,000 species, of which 73 % are epiphytes (Dressler, 1993; Castillo-Pérez *et al.,* 2018). Except in polar areas, the most arid deserts and snowy peaks, orchids can be found in all ecosystems of the planet (Huerta-Espinoza, 2018), although their presence is more important in the tropical region where almost 56 % of the species are found (Espejo-Serna *et al.,* 2002) and, in particular, the tropical countries of America have the highest number of endemisms (Espejo-Serna *et al.,* 2002; Hágsater *et al.,* 2005). In Mexico, the most updated count of orchids includes a list of 167 genera and 1,315 species and infraspecies, being the third most important family in richness terms (Solano-Gómez, 2019). In the country, the Sierra Madre del Sur is the ecoregion with the highest species diversity

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(59 % for the total number of species of Mexican orchids) and one of the highest endemism (26 % for the total number of endemic species), while the mountain mesophyll and mixed pine-oak forests host 67-71 % of the species (Huerta-Espinoza, 2018; Solano-Gómez, 2019). There are 596 species endemic to Mexico (Espejo-Serna, 2012). The highest percentage of endemic orchids is found in Latin America, comprising approximately 35 % of species and 8 % of genera (Soto, 1988). Out of the total number of species, 192 are considered into some risk category (SEMARNAT, 2019). Of the total number of Mexican endemic orchids, 73 species (40.3 %) are classified under some category of protection according to the Mexican Official Standard NOM-059-SEMARNAT 2010 (SEMARNAT, 2019; Castillo-Pérez *et al.,* 2018). However, the extinction of more than 20 orchid species has already been documented (Hágsater *et al.,* 2005). In Jalisco, approximately 381 orchid species occur (Villaseñor, 2016), making it the second family with the highest number of endemics (9 % of total endemics) with 15 genera and 33 species (Hernández-López, 2017; Castillo-Pérez *et al.,* 2018). For the Puerto Vallarta municipality, about 37 species have been registered (Flores-Argüelles, 2020; Flores-Argüelles *et al*., 2022; Villaseñor, 2016; Naturalista, 2023; GBIF, 2023). In addition to their biological importance, epiphytic orchids are an essential plant component in the forests they inhabit, playing a crucial role in the dynamics and functioning of the ecosystem by providing habitat and food for many vertebrates and invertebrates. Orchids, like other epiphytes such as bromeliads, are sensitive to environmental changes and are often used as bioindicators due to features such as distribution, abundance, dispersal, or reproductive success that could indicate environmental conditions of interest (Flores-Argüelles *et al.,* 2022).

Due to their attractiveness, epiphytic orchids are used as ornaments in houses and commercial establishments, particularly in Puerto Vallarta, Jalisco, but the identity of the species is unknown. Given the lack of reports dealing with such a panorama, the present study aims to analyze the richness and abundance of epiphytic ornamental orchids used in Puerto Vallarta, Mexico. The study seeks to answer the following questions: Is the use of orchids related to their distribution? Which flower color is most commonly used? Which orchid species are dominant? Additionally, to contribute to and promote the study of endemic and native epiphytic orchid species in the region, the study identifies extrinsic and intrinsic factors potentially threatening these species. Considering that Jalisco ranks second in terms of orchid endemism (Castillo-Pérez *et al.,* 2018), the municipality of Puerto Vallarta is situated within the 'Centro Talpa-Cuale' area, known for its high concentration of endemic orchid species (Reynoso-Dueñas, 2004; Reynoso-Dueñas *et al.,* 2006). However, it is acknowledged that botanical explorations and inventories in the region have been sporadic, with some areas remaining unexplored and requiring floristic studies. This is particularly crucial given the presence of extensive tropical deciduous and sub-deciduous forests in parts of the Northern Coast region of Jalisco and the northernmost section of the Sierra Madre del Sur (Ceballos *et al.,* 2010; Castillo-Pérez *et al.,* 2018; Huerta-Espinoza, 2018). Nevertheless, these forests face threats from various changes in land use, including deforestation for agricultural purposes, intensive grazing, periodic fires, and, more recently, the rapid expansion of urban areas and tourism (Morales-Hernández *et al.,* 2016).

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Material and methods

Study area

The study was conducted in the Puerto Vallarta municipality, located in the western region of Jalisco state (Figure 1). It has a population of 291,839 people according to the IIEG (2020). The predominant climate is warm sub-humid (CEA, 2015), with an average annual temperature of 21.8 °C, a maximum of 31.6 °C, and a minimum of 13.4 °C. The average annual precipitation is 1,385 mm, and the altitude ranges from 0 to 1,861 m.a.s.l. (SIEG, 2023). The municipality features tropical deciduous and sub-deciduous vegetation, with patches of *Quercus* forest at higher elevations (Ramírez-Delgadillo & Cupul-Magaña, 1999).

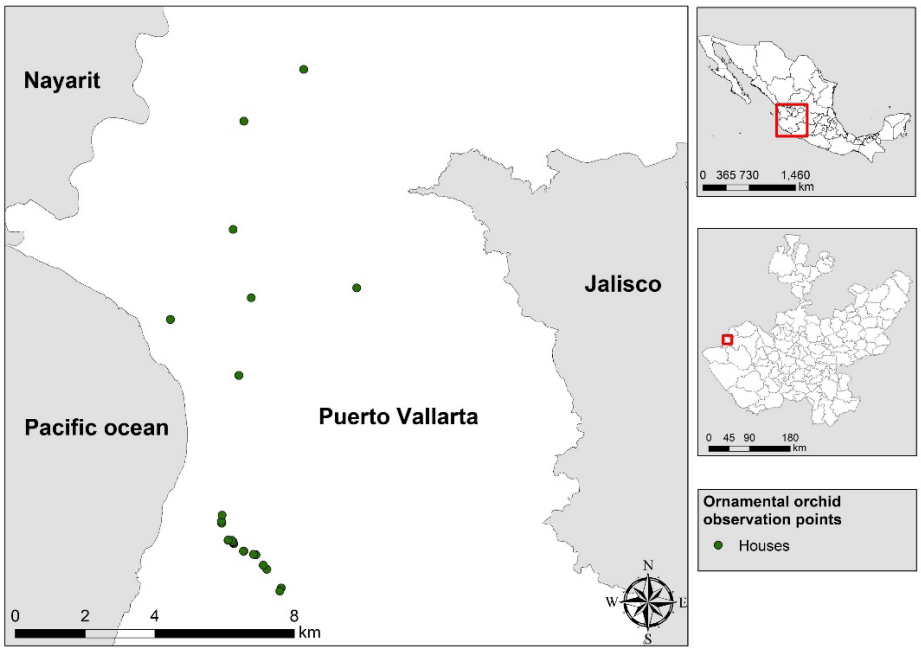

Figure 1. Location of houses and commercial establishments in the Puerto Vallarta municipality, Jalisco, Mexico, where ornamental epiphytic orchids were found.

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Direct observation tours of houses and commercial establishments

The registration of ornamental orchids was conducted in 24 houses and two commercial establishments from June to October 2022. The surveys were carried out in neighborhoods near the Cuale River and downtown Puerto Vallarta. Additionally, photographs were provided by colleagues and relatives who have ornamental epiphytic orchids, with the condition that the house is located within the municipality. Permission was sought from the owners of houses with epiphytic orchids in their playgrounds, gardens, terraces, and front garages to photograph the plants and later determine their taxonomic identity and abundance. Furthermore, the substrates used to grow the wild specimens were documented (Figure 2).

Taxonomic identity

From direct observation and photographs, the native and endemic orchids present in the houses could be identified at the species level, while for most of the exotic orchids, only the genus could be identified. Verification of the scientific names and taxonomic authority was obtained from the website Tropicos (2023) and the updated catalog of taxonomic authorities of *Orchidaceae* of Mexico (Solano-Gómez *et al.,* 2020).

Species distribution

Species distribution was assessed using the catalog of native vascular plants of Mexico (Villaseñor, 2016) and the catalog of taxonomic authorities of *Orchidaceae* of Mexico (Solano-Gómez *et al.,* 2020). Based on their natural distribution, epiphytic orchids were classified into a) Endemic, those species whose distribution in the wild occurs exclusively in Mexico; b) Native, those species whose natural range covers part or all of Mexico; and c) Exotic, those species whose distribution in the wild occurs outside of Mexico (Catford & Jansson, 2014).

Flower color

The endemic and native orchids found in Puerto Vallarta exhibit a wide range of colors in the petals of the corolla, which are referred to generically as flowers in this study. Flowers classification included eight categories: purple, white/green (approximately 70 % white and 30 % green), yellow, green/white (approximately 70 % green and 30 % white), brown, orange, pink, and variable. Except for *Spathoglottis plicata*, the exotic species were grouped under the variable color category since several individuals were either unidentified at the species level or did not have flowers at the recording time.

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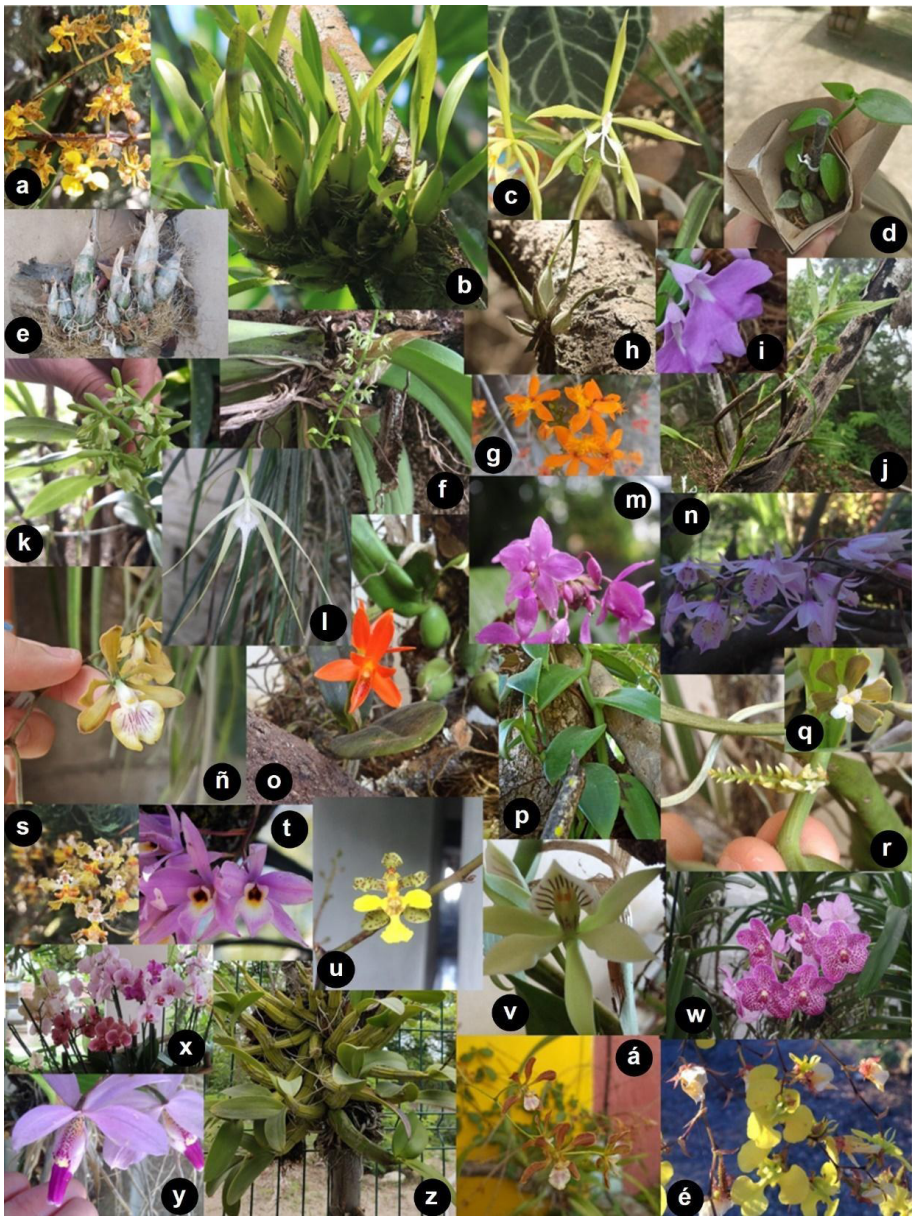

Figure 2. Species of ornamental epiphytic orchids found in houses and commercial establishments in Puerto Vallarta, Jalisco, Mexico.

a) *Trichocentrum brachyphyllum;* b) *Oncidium leleui*; c) *Epidendrum cilioccidentale*, d) *Vanilla planifolia*; e) *Clowesia dodsoniana*; f) *Notylia orbicularis* subsp. *warfordiae*; g) *Epidendrum* sp; h) *Scaphyglottis sessilis*; i) *Epidendrum longicaule*; j) *Scaphyglottis imbricata*; k) *Epidendrum chlorops*; l) *Brassavola cucullata*; m) *Spathoglottis plicata*; n) *Barkeria palmeri*; ñ) *Encyclia trachycarpa*; o) *Guarianthe aurantiaca*; p) *Vanilla pompona*; q) *Encyclia suaveolens*; r) *Campylocentrum micranthum*; s) *Trichocentrum natalieae*; t) *Laelia rubescens*; u) *Trichocentrum pendulum*; v) *Prosthechea madrensis*; w) *Vanda* sp; x) *Phalaenopsis* sp; y) *Barkeria uniflora*; z) *Myrmecophila galeottiana*; á) *Encyclia spatella*; and é) *Erycina echinata*.

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Extrinsic and intrinsic factors threatening epiphytic orchid species

Based on the knowledge gathered from the fieldwork and the limited literature on some of the identified species, extrinsic and intrinsic factors that potentially threaten the populations or habitat of the identified endemic and native orchids were identified, factors proposed by Solano (2021) and applied to the orchid species of Veracruz.

Data analysis

The richness and abundance of data (dependent variables) did not exhibit a normal distribution or homogeneity of variances, as analyzed with the Shapiro-Wilk test and Levene's test, respectively. Therefore, non-parametric tests (Kruskal-Wallis) were performed to determine if there are differences in the preference of orchid species according to the type of distribution and flower color (independent variables). When significant differences were observed, a posteriori Mann-Whitney U test was employed to compare between groups, with the corrected *P-value* reported according to Bonferroni. All analyses were conducted using the PAST program (Hammer *et al.,* 2001). Additionally, species dominance was ranked based on an Olmstead-Tukey (1947) diagram. This involved plotting the occurrence frequency and total abundance per species on a Cartesian plane, which was then subdivided into four regions by median ranks. The relative position of each species in the quadrants indicates its level of dominance; that is, rare species are infrequent and poorly abundant, while dominant species are very frequent and abundant. Typical (constant) and occasional species were also included.

Results

Richness and abundance of orchids for ornamental and domestic use

In the houses and commercial establishments, 521 orchid individuals from 16 genera and 33 species were registered (Table 1). The number of species found per house or commercial establishment ranged from 1 to 24, with individual orchid counts ranging from 1 to 284.

According to flower color, orchids with white/green, followed by green/white and yellow flowers presented the highest number of species (Figure 3). Endemic species had six flower colors, while native species had five flower colors.

According to species distribution, 16 orchid species are endemic to Mexico, nine are native, and eight are exotic (see Table 1, Figure 3). On average, there is a greater richness of ornamental endemic orchids in the houses of Puerto Vallarta (χ^2 = 12.99; df = 2; p = 0.0015; Figure 4a). The richness of endemics is significantly different from the richness of exotics on average (p = 0.0033). The highest number of endemic species recorded per house was 15, with six native species and eight exotic species. However, no differences in abundance were found according to distribution

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type (χ^2 = 4.31; df = 2; p = 0.1156; Figure 4b). The highest number of endemic individuals recorded per house was 43, with 53 natives and 191 exotics.

According to flower color, one to seven flower colors were found in houses and commercial establishments (Figure 3). No differences were found in the richness (χ^2 = 5.07; df = 7; p = 0.6511, Figure 4c) and number of individuals (χ^2 = 3.53; df = 7; p = 0.8313; Figure 4d) of ornamental orchids according to flower color. In one house, up to five species with yellow flowers and five species with white-green flowers were recorded. The highest number of orchid individuals recorded per house was 46 and 20 for white-green flower color, followed by 17 for purple and green-white flower colors.

In houses and commercial establishments in Puerto Vallarta, endemic, native, and exotic orchids were found in gardens, playgrounds, and garages, mounted in pots, tiles, trunks, and even on trees (Figure 5).

Table 1. Ornamental epiphytic orchid species identified in houses and commercial establishments in Puerto Vallarta.

Species	Code	Homes and commercial establishments													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Barkeria palmeri (Rolfe) Schltr.	Bapa						■								
Barkeria uniflora (Lex.) Dressler & Halb.	Baun														
Brassavola cucullata (L.) R. Br.	Brcu														
Campylocentrum micranthum (Lindl.) Maury	Cami														
Clowesia dodsoniana E. Aguirre	Cldo	■	■		■			■							
Encyclia spatella (Rchb. f.) Schltr.	Ensp	■						■		■					
Encyclia trachycarpa (Lindl.) Schltr.	Enter									■				■	■
Encyclia suaveolens Dressler	Ensu														
Epidendrum chlorops Rchb. f.	Epch														
Epidendrum cilioccidentale Hágsater & L. Sánchez	Epci		■					■	■	■					
Epidendrum longicaule (L.O. Williams) L.O. Williams	Eplo														
Erycina echinata (Kunth) Lindl.	Erec														
Guarianthe aurantiaca (Bateman) Dressler & W.E. Higgins	Wow	■	■							■				■	
Laelia rubescens Lindl.	Laru													■	
Myrmecophila galeottiana (A. Rich.) Rolfe	Myga							■					■	■	■
Notylia orbicularis subsp. *warfordiae* Salazar	Noor														

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Continuation

Table 1. Ornamental epiphytic orchid species identified in houses and commercial establishments in Puerto Vallarta.

Species	Code	Homes and commercial establishments													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Oncidium leleui R. Jiménez & Soto Arenas	Onle														
Prosthechea madrensis (Schltr.) Karremans	Prch														
Scaphyglottis imbricata (Lindl.) Dressler	Scim														
Scaphyglottis sessilis (Rchb. f.) Foldats	Scse														
Trichocentrum brachyphyllum (Lindl.) R. Jiménez	Trbr														
Trichocentrum natalieae (Balam & Carnevali) R. Jiménez & Solano	Trna														
Trichocentrum pendulum (Carnevali & Cetzal) R. Jiménez & Solano	Trpe														
Vanilla planifolia Andrews	Vapl														
Vanilla pompona Schiede	Vapo														
Phalaenopsis sp.	Phsp														
Spathoglottis plicata Blume	Sppl														
Vanda sp.	Vasp														
Epidendrum sp.	Epra														
Cattleya sp.	Casp														
Dendrobium bigibbum Lindl.	Debi														
Dendrobium nobile Lindl.	Deno														
Oncidium sp.	Onsp														

Distribution in the wild (DITW): endemic (green cell), native (yellow cell), and exotic (red cell); *Commercial establishments.

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Continuation

Table 1. Ornamental epiphytic orchid species identified in houses and commercial establishments in Puerto Vallarta.

Species	Code	Homes and commercial establishments											
		15	16	17	18	19	20	21	22*	23	24	25	26*
Barkeria palmeri (Rolfe) Schltr.	Bapa												
Barkeria uniflora (Lex.) Dressler & Halb.	Baun												
Brassavola cucullata (L.) R. Br.	Brcu												
Campylocentrum micranthum (Lindl.) Maury	Cami												
Clowesia dodsoniana E. Aguirre	Cldo												
Encyclia spatella (Rchb. f.) Schltr.	Ensp												
Encyclia trachycarpa (Lindl.) Schltr.	Enter												
Encyclia suaveolens Dressler	Ensu												
Epidendrum chlorops Rchb. f.	Epch												
Epidendrum cilioccidentale Hágsater & L. Sánchez	Epci												
Epidendrum longicaule (L.O. Williams) L.O. Williams	Eplo												
Erycina echinata (Kunth) Lindl.	Erec												
Guarianthe aurantiaca (Bateman) Dressler & W.E. Higgins	Wow												
Laelia rubescens Lindl.	Laru												
Myrmecophila galeottiana (A. Rich.) Rolfe	Myga												
Notylia orbicularis subsp. *warfordiae* Salazar	Noor												
Oncidium leleui R. Jiménez & Soto Arenas	Onle												
Prosthechea madrensis (Schltr.) Karremans	Prch												
Scaphyglottis imbricata (Lindl.) Dressler	Scim												
Scaphyglottis sessilis (Rchb. f.) Foldats	Scse												
Trichocentrum brachyphyllum (Lindl.) R. Jiménez	Trbr												
Trichocentrum natalieae (Balam & Carnevali) R. Jiménez & Solano	Trna												
Trichocentrum pendulum (Carnevali & Cetzal) R. Jiménez & Solano	Trpe												
Vanilla planifolia Andrews	Vapl												
Vanilla pompona Schiede	Vapo												
Phalaenopsis sp.	Phsp												
Spathoglottis plicata Blume	Sppl												
Vanda sp.	Vasp												
Epidendrum sp.	Epra												
Cattleya sp.	Casp												
Dendrobium bigibbum Lindl.	Debi												
Dendrobium nobile Lindl.	Deno												
Oncidium sp.	Onsp												

Distribution in the wild (DITW): endemic (green cell), native (yellow cell), and exotic (red cell); *Commercial establishments.

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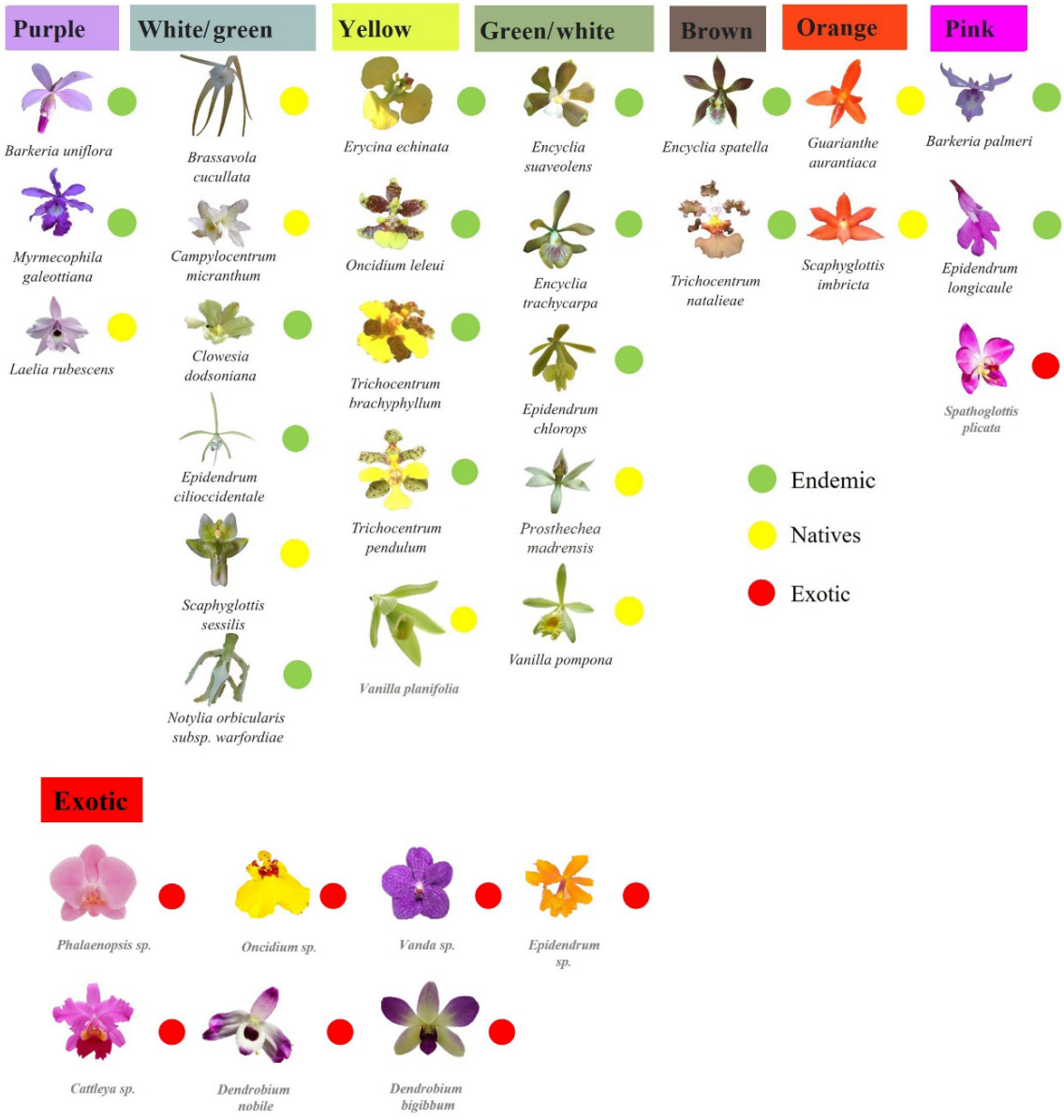

Figure 3. Classification of Puerto Vallarta ornamental epiphytic orchids according to their flower color and wild distribution.

Source: own elaboration.

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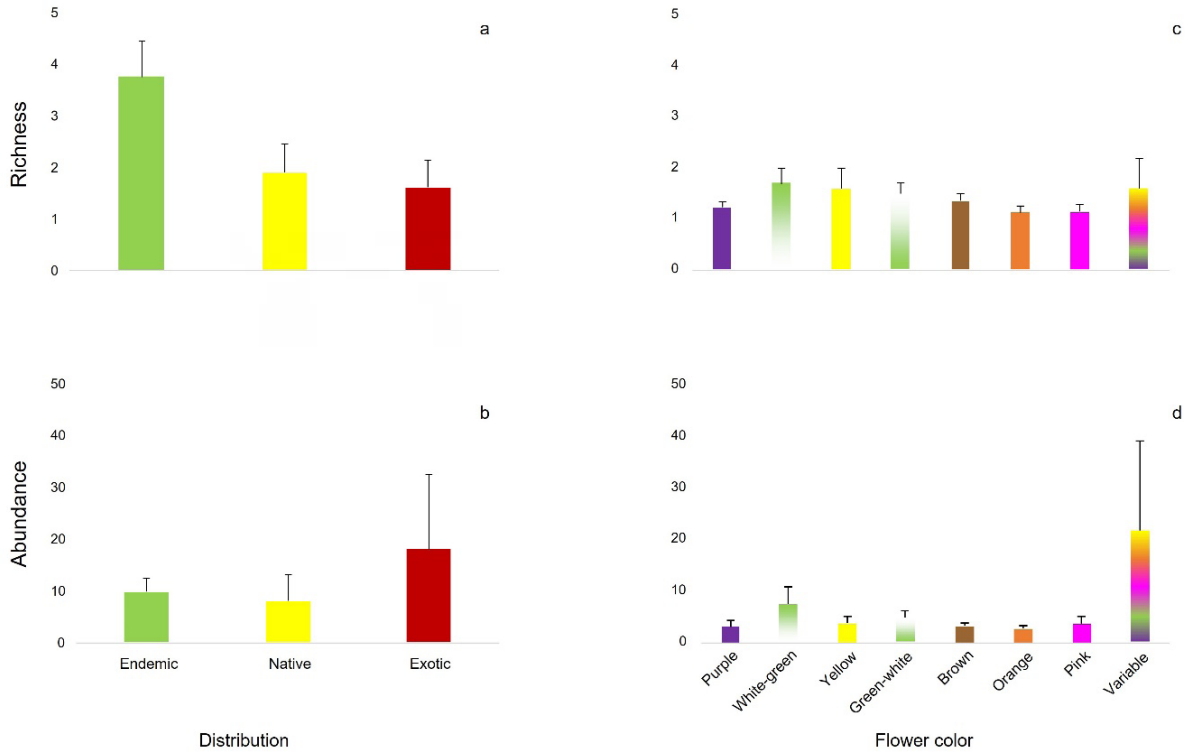

Figure 4. Richness and abundance of ornamental epiphytic orchids in houses and commercial establishments in Puerto Vallarta, according to their distribution (a, b) and flower color (c, d).

Figure 5. Ornamental epiphytic orchids and the different substrates in which they are found in homes and commercial establishments in Puerto Vallarta, Jalisco, Mexico.

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Type of orchid for ornamental use according to its frequency and abundance

The exotic species *Phalaenopsis* sp. (Phsp), present in 10 houses and comprising 136 individuals, was the most dominant ornamental epiphytic orchid. Among this group, the endemic species *M. galeottiana (*Myga), *T. natalieae* (Trna), and *O. leleui* (Onle) stand out for their frequency of ornamental use, with 22, 31, and 22 individuals, respectively. Thirty-six percent of the ornamental epiphytic orchids are dominant, meaning they are both frequent (present in 3 to 12 houses and commercial establishments) and abundant (7 to 136 individuals) (Figure 6). Additionally, 39 % of the species were rare, found in only 1 to 2 houses and commercial establishments, with 1 to 6 individuals each. Six species were particularly rare, found in only one house with one individual, such as *E. longicaule*. Only 24 % of the species were occasional, occurring in 1 to 2 houses and commercial establishments, with 7 to 32 individuals each. Three exotic species fall into this category, such as *Vanda sp*., *Cattleya sp*., and *D. bigibbum*, found in 1 to 2 houses with 8 to 28 individuals.

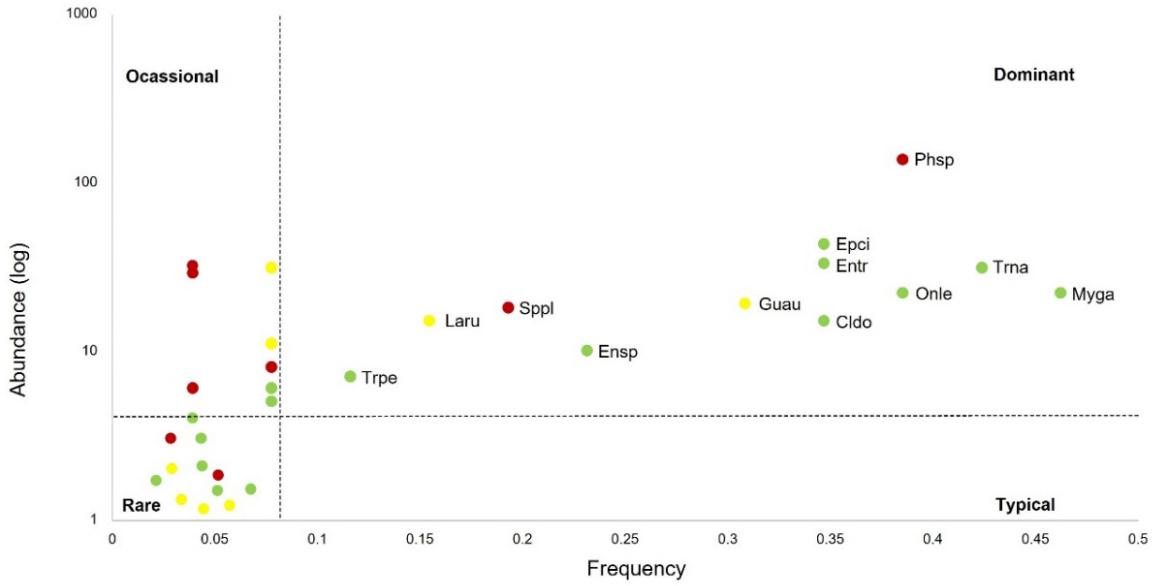

Figure 6. Classification of the ornamental epiphytic orchids of Puerto Vallarta according to the frequency of appearance and their abundance.

Green circles represent endemic species, yellow circles represent native species, and red circles represent exotic species. Species codes are provided in Table 1.

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Extrinsic and intrinsic factors threatening epiphytic orchid species.

Identifying extrinsic and intrinsic factors that potentially threaten the populations and/or habitats of endemic and native orchids used as ornamentals within Puerto Vallarta offers two advantages (Table 2). First, it helps identify the factors that most frequently affect the species, and second, it identifies the species facing the greatest number of threats. In this context, land use change resulting from agricultural activities and the expansion of extensive cattle ranching are identified as extrinsic factors that potentially threaten the populations or habitats of endemic and native orchids. Intrinsic factors, such as low population density, high habitat specificity, and widely separated populations, also pose risks to epiphytic orchid populations in the wild. Among the epiphytic orchids facing the greatest number of threats and thus at the highest risk are the native species *E. trachycarpa* and the endemic species *C. dodsoniana* and *M. galeottiana.*

Discussion

Obtained data reveal that 68 %, 7 %, and 2 % of the municipal, state, and national orchid flora, respectively, have the potential to be found in houses and commercial establishments in Puerto Vallarta (Flores-Argüelles, 2020; Flores-Argüelles *et al.,* 2022; Villaseñor *et al.,* 2016; Solano *et al.,* 2019). However, the documentation regarding the use of epiphytic orchids as ornamentals in gardens, playgrounds, and garages is lacking. Consequently, direct comparisons with studies like the one on orchid species cultivated in home gardens in Calakmul, Campeche (Gamboa, 2011), are limited. While the number of native epiphytic orchid species is comparable between the two studies, with both considering 31 species, the study in Calakmul provides more comprehensive biological, ecological, and management information. This includes aspects such as phenology, abundance, risk category, and distribution of wildlife in general and in Mexico. Additionally, it covers the preferences of the population for using these species, the general conditions of the vegetation, the habitat from which they are obtained for management, and knowledge of their propagation along with other plants cultivated in home gardens. Furthermore, the presence of 25 species of endemic and native orchids in 28 private spaces can be explained by the preference for this type of vascular plant and the representativeness of the sample. Only 12 species recorded in the municipality were not observed, including *Aspidogyne vaginata*, *Bletia purpurea*, *Cranichis ciliilabia*, *Erycina pusilla*, *Govenia sp*., *Macroclinium lexarzanum*, *Meiracylium gemma*, *Notylia trisepala*, *Prosthechea madrensis*, *Prosthechea trulla*, *Sarcoglottis sceptrodes*, and *Stanhopea sp*. (Villaseñor *et al.,* 2016). It is acknowledged that this study was not exhaustive, as it did not cover the entire 1,340 hectares of urban land in the municipality of Puerto Vallarta (SIEG, 2023).

The preference for using epiphytic orchids for ornamentation is strongly influenced by their distribution, with significant emphasis placed on the use of endemic epiphytic orchids. This finding is particularly notable given that Jalisco state ranks second in terms of the highest number of endemic orchids (Castillo-Pérez *et al.,* 2018). Additionally, over the last 15 years, 27 new species have been described in Jalisco, highlighting the potential for discovering new species in the North

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Coast region (Huerta-Espinoza, 2018; Solano *et al.,* 2019). Fortunately, ecological information is emerging for some orchid species identified in this study, such as *B. cucullata*, *C. dodsoniana*, *E. cilioccidentale*, *G. aurantiaca*, *P. madrensis*, *S. imbricata*, and *T. pendulum*. These species were recorded in Cabo Corrientes, an adjacent municipality to Puerto Vallarta and part of the northern coastal region of Jalisco (Flores-Argüelles, 2020; Flores-Argüelles *et al.,* 2022). It was observed that the selection of ornamental epiphytic orchids is not determined by flower color but rather by the duration and synchrony of flowering time. According to published literature and field and online observations (Naturalist, 2023), most of the endemic and native orchid species recorded have flowers that last three to seven months, with peak flowering occurring from February to June. Therefore, achieving flowering plants throughout the year requires the inclusion of several species with alternating phenology.

Table 2. Extrinsic and intrinsic factors that potentially threaten the endemic (green cell) and native (yellow cell) ornamental epiphytic orchid species of the Puerto Vallarta municipality. Cells in red show lack of data.

Species	Extrinsic factors				
	1a. Change in land use due to agricultural activities	1b. Expansion of intensive livestock farming	1c. Increase of urban centers, opening of new roads and tourism development	1d. Forest management and timber extraction	1e. Extractive industry activities
Barkeria palmeri	*	*	*	*	
Barkeria uniflora	*	*			
Brassavola cucullata	*	*	*		
Campylocentrum micranthum	*	*			
Clowesia dodsoniana	*	*		*	
Encyclia spatella	*	*		*	
Encyclia trachycarpa	*	*	*	*	
Encyclia suaveolens	*	*		*	
Epidendrum chlorops	*	*			
Epidendrum cilioccidentale	*				
Epidendrum longicaule	*				
Erycina echinata	*				

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Table 2. Extrinsic and intrinsic factors that potentially threaten the endemic (green cell) and native (yellow cell) ornamental epiphytic orchid species of the Puerto Vallarta municipality. Cells in red show lack of data.

Species	Extrinsic factors				
	1a. Change in land use due to agricultural activities	1b. Expansion of intensive livestock farming	1c. Increase of urban centers, opening of new roads and tourism development	1d. Forest management and timber extraction	1e. Extractive industry activities
Guarianthe aurantiaca	*	*			
Laelia rubescens	*				
Myrmecophila galeottiana	*	*	*	*	
Notylia orbicularis	*				
Oncidium leleui	*	*		*	
Prosthechea madrensis	*	*		*	
Scaphyglottis imbricata	*				
Scaphyglottis sessilis	*	*			
Trichocentrum brachyphyllum	*	*		*	
Trichocentrum natalieae	*	*		*	
Trichocentrum pendulum	*	*		*	
Vanilla pompona	*		*		

Factors were taken from Solano 2021.

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Table 2. Extrinsic and intrinsic factors that potentially threaten the endemic (green cell) and native (yellow cell) ornamental epiphytic orchid species of the Puerto Vallarta municipality. Cells in red show lack of data.

Species	Intrinsic factors					
	2a. Low population density	2b. High habitat specificity	2c. Very specific relationships with other organisms	2d. Widely separated populations	2e. Restricted geographic distribution	2f. Highly specialized reproductive systems
Barkeria palmeri						
Barkeria uniflora	*	*		*		
Brassavola cucullata						
Campylocentrum micranthum		*				
Clowesia dodsoniana	*	*		*		
Encyclia spatella	*	*		*		
Encyclia trachycarpa	*	*		*		
Encyclia suaveolens	*	*		*		
Epidendrum chlorops	*	*		*	*	
Epidendrum cilioccidentale						
Epidendrum longicaule	*	*		*	*	
Erycina echinata		*		*		
Guarianthe aurantiaca						
Laelia rubescens	*	*		*	*	
Myrmecophila galeottiana		*	*			
Notylia orbicularis						
Oncidium leleui						
Prosthechea madrensis	*	*				
Scaphyglottis imbricata	*	*				
Scaphyglottis sessilis	*	*				
Trichocentrum brachyphyllum						
Trichocentrum natalieae						
Trichocentrum pendulum						
Vanilla pompona	*	*		*	*	

Factors were taken from Solano 2021.

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Continuation

Table 2. Extrinsic and intrinsic factors that potentially threaten the endemic (green cell) and native (yellow cell) ornamental epiphytic orchid species of the Puerto Vallarta municipality. Cells in red show lack of data.

Species	Others	
	3. Extraction of wild specimens	4. Effects related to climate change
Barkeria palmeri		
Barkeria uniflora		
Brassavola cucullata		
Campylocentrum micranthum		
Clowesia dodsoniana	*	
Encyclia spatella		
Encyclia trachycarpa	*	
Encyclia suaveolens		
Epidendrum chlorops		
Epidendrum cilioccidentale		
Epidendrum longicaule		
Erycina echinata		
Guarianthe aurantiaca	*	
Laelia rubescens		
Myrmecophila galeottiana	*	
Notylia orbicularis		
Oncidium leleui	*	
Prosthechea madrensis		
Scaphyglottis imbricata		
Scaphyglottis sessilis		
Trichocentrum brachyphyllum		
Trichocentrum natalieae	*	
Trichocentrum pendulum		
Vanilla pompona		

Factors were taken from Solano 2021.

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Endemic and native epiphytic orchids are prominently featured as ornamental species. Among them are native species like *G. aurantiaca* and *L. rubescens*, which are even sold on e-commerce platforms (Espejo-Cruz *et al.,* 2023). Several features make orchids attractive in this trade: being native to Mexico (origin), preferably endemic or at-risk (rarity status), and having showy flowers (horticultural potential). For instance, *G. aurantiaca,* on average, is priced at 18.54 pesos in traditional markets, while on e-commerce platforms, it commands a significantly higher price of 430.50 pesos (Espejo-Cruz *et al.,* 2023). This price disparity incentivizes illegal extraction from natural habitats and subsequent sale on e-commerce platforms in the absence of regulation by environmental authorities. Given the frequency of using endemic orchids and the potential for continued use in the region, urgent measures are needed to conduct population studies. These studies should cover various aspects such as fecundity, reproductive systems, population growth rates, recruitment, age structure, levels of genetic variation, and gene flow, as well as interactions with hosts and pollinators, among others. Such research would provide crucial insights into the biological and ecological aspects of these species that are currently unknown. Unfortunately, the status of natural populations of the 25 endemic and native species recorded in this study, both within the municipality and the region, remains unknown. Consequently, it is challenging to determine with certainty whether illegal extraction, combined with inadequate habitat management in unique habitats where several of these species occur such as the case of *E. trachycarpa* is leading to the population depletion.

There is a possibility that the epiphytic orchids discovered in houses and commercial establishments are naturally fallen individuals that can survive in the soil for at least two years, as demonstrated in previous research on *Laelia furfuracea* (Orozco-Ibarrola *et al.,* 2021). In this study, it was found that almost 6 % of the plants of this species were found in the soil, suggesting that fallen orchids could serve as an important source of plant material. Utilizing fallen orchids could potentially reduce harvesting pressure on natural populations. However, orchids in the ground are more susceptible to damage, and their aesthetic value may decrease as a result. Furthermore, during field trips within the tropical deciduous and sub-deciduous forests of the municipality of Puerto Vallarta, forgotten specimens of epiphytic orchids were discovered. These specimens appeared to have been abandoned after being extracted from their natural habitat, with part of the branch of their host still attached (Figure 7). This practice of extraction without a management plan and lacking sustainable techniques for use poses a significant threat to orchid populations and their habitats.

Remarkably, in Puerto Vallarta and the northern coast of Jalisco, there is a need to document the use of epiphytic orchids from an ethnoecological perspective. This approach should incorporate intrinsic factors identified in this study, as well as cultural and economic aspects. Similar investigations have been conducted for other orchids, such as *L. autumnalis*, and could serve as a starting point to generate knowledge about native and endemic species (Beltrán-Rodríguez *et al.,* 2012). From an ethnoecological viewpoint, and integrating various factors and aspects, three key projects should be addressed. Firstly, research should focus on the distribution and population density of different orchid species to determine their high habitat specificity. Secondly, collection practices and sustainable management techniques need to be investigated to identify collection sites of different orchid species. This involves determining whether the collection is carried out by

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individuals or multiple family members, whether it occurs in ejido sites or randomly, and whether collectors know the orchid habitat and phenology. Additionally, the level of harvest, i.e. how many individuals with or without flowers are obtained per year and their sale prices should be documented. Thirdly, it is crucial to gather information on the level of illicit extraction and commercialization of epiphytic orchids, the status of affected populations, and the socioeconomic profile of sellers. This data is essential for designing effective conservation strategies for this highly threatened and vulnerable group of vascular plants (Jiménez-López *et al.,* 2019a, 2019b).

Figure 7. Ornamental epiphytic orchid preserving the branch of its host found in the surrounding tropical deciduous forest of Puerto Vallarta, Jalisco, Mexico.

Recently, experts in orchid harvest, ecology, demography, and conservation have developed a key to identifying sustainable methods for orchid population harvests. This guide offers a set of considerations that collectors and natural resource managers can utilize and adapt to local contexts, thereby contributing to long-term sustainability (Ticktin *et al.,* 2023). The guide, which is based on 27 species and 12 characteristics related to abundance and distribution, growth and reproduction, local management practices, and demand, can serve as a framework for generating information for other endemic and native species lacking harvest data, such as epiphytic orchids used as ornamentals in Puerto Vallarta.

Therefore, there is a vast scope to study epiphytic orchids in the Puerto Vallarta region, not only in urban areas but also in the tropical and temperate forests found in the municipality. This area,

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part of the Sierra Madre del Sur, remains largely unexplored and offers favorable environmental conditions for orchids, presenting opportunities for further discoveries (Huerta-Espinoza, 2018; Solano *et al.,* 2019). Unprotected regions like the North Coast of Jalisco, characterized by high orchid diversity, could be incorporated into new strategies for biodiversity conservation (Ceballos *et al.,* 2010). Considering their close biological-ecological interactions with hosts, pollinators, mycorrhizal fungi, and habitat preferences, orchids can be viewed as an umbrella group in conservation labors aimed at protecting entire ecosystems (Solano *et al.,* 2019).

Conclusions

In houses and commercial establishments of Puerto Vallarta, two-thirds of the endemic and native orchid species of the region are utilized as ornamentals, while exotic orchids, though less common, are restricted to a few species. There is a clear preference for endemic species over native and introduced species, with flower color not playing a significant role in determining the ornamental use of epiphytic orchids. Extrinsic factors such as changes in land use due to agricultural activities and the expansion of extensive cattle ranching, along with intrinsic factors like low population density, high habitat specificity, and widely separated populations, pose potential threats to the populations or habitat of endemic and native orchids in the region. To address the use of endemic and native epiphytic orchids, we propose an initial pragmatic approach to identify their extraction sites. However, this represents just the first step. There is a critical need for comprehensive information on various biological, ecological, economic, and social aspects related to the 25 species of epiphytic orchids. We have outlined a series of topics for investigation to promote the study of this group in the region, recognizing the complexity and diversity of orchid life histories.

Authors contribution

Conceptualization of work, SQ; methodology development, CRP, QS; experimental validation, CRP, QS; analysis of results, CRP, QS; data management, CRP, QS; manuscript writing and preparation, CRP, QS; drafting, revising, and editing, CRP, QS; project manager, QS; photographs CRP.

All authors of this manuscript have read and accepted the published version of the manuscript.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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