Design of an orchid conservation trail in Ixtaczoquitlán, Veracruz, Mexico

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ABSTRACT

Objective: To raise awareness about the ecological importance of orchids and to promote the species commercialized by a company focused on their production through the design of a trail.

Design/Methodology/Approach: A diagnosis of the plot was carried out to identify its characteristics and points of interest. A trail was designed to connect the most outstanding points. Native trees, which are the habitat of orchids, were subsequently planted to establish the outdoor collections.

Results: The appeal of the place and the established phorophytes were taken into consideration to design the trail. Likewise, recommendations were made on what species of orchids should be planted in each station along the trail.

Study Limitations/Implications: Evaluating visitor experience is pending. The trail lacks infrastructure for people with disabilities. The trail is located in an area subjected to anthropization and it will take several years before orchids can be established on the trees planted in July 2023.

Findings/Conclusions: Trails are a useful tool to promote the conservation of native orchids; however, under anthropization conditions, it should be subjected to a systematized implementation to provide the climate and phorophyte conditions necessary for the survival of orchids.

Keywords: Trail design, orchid trail, phorophytes, native orchids, introduced orchids, alternative tourism, hiking.

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INTRODUCTION

Trails, as part of the natural environment, facilitate recreational activities and contact with nature (Phillips *et al.*, 2014). Outdoor activities (*e.g.*, hiking and picnics) are considered part of alternative tourism or rural tourism (Phillips *et al.*, 2014; Baltazar-Bernal, 2024). Therefore, each trail must be designed according to its target audience (Hernández-Ulate *et al.*, 2015). Consequently, designing a trail requires surveys and assessments to identify the biotic and abiotic elements of the area, therefore avoiding soil erosion, soil compaction, and disturbance of local species, among other factors (Phillips *et al.*, 2014). In this sense, trails must be designed comprehensively to avoid damaging natural resources and to encourage the study about the diversity of flora, including native orchids and their environmental functions (Rahadi *et al.*, 2018; Baltazar-Bernal, 2024). Therefore, Light y Macconaill (2008) suggests establishing clear limits on the trails and instructing visitors to stay within those boundaries to keep orchids in good condition.

There are two types of trails: guided and self-guided. As their name indicates, the former require a guide and the latter are designed for areas in which a high number of visitors walk the trail on their own, which requires sufficient signage and/or information material to enhance the enjoyment of the visit (Lucero *et al.*, 2021). Forest orchids are potentially threatened by deforestation and illegal felling (Solano-Gómez *et al.*, 2019); therefore, conservation awareness should be increased, recognizing threats to reduce their impact and having adequate management (Wraith and Pickering, 2017). The diversity of wild orchids and bromeliads found in forest trails could become tourist attractions (Baltazar-Bernal *et al.*, 2014). Outdoor orchid collections have different species displayed in a natural space, enhancing the experience of the visitors (Semiarti *et al.*, 2020).

Orchid trails promote the integration of conservation activities, based on the observation of the different elements that compose the environment (Rodríguez-Gutiérrez *et al.*, 2019; Baltazar-Bernal, 2023). Similar studies have been carried out in the state of Veracruz aimed at designing an orchid trail in anthropized environments, such as a rural community (Baltazar-Bernal *et al.*, 2014) and an educational institution (Baltazar-Bernal, 2023). However, further research about trails is fundamental to promote orchid conservation in other types of anthropized environments, such as private companies. Therefore, the objective of this study was to design an orchid trail for a company in Ixtaczoquitlán, Veracruz, Mexico. The ultimate purpose was to raise awareness about the ecological importance of orchids and to promote the species that they commercialize. The hypothesis was that the study site will have the climate, phorophytes, vegetation cover, and natural appeal required to design an orchid trail.

MATERIALS AND METHODS

The methodology proposed by SECTUR (2005) and modified by Baltazar-Bernal *et al.* (2014) was used to design this trail. The design phases were: (1) diagnosis and planning and (2) design and construction.

First phase: Diagnosis and planning

The first phase consisted of a bibliographic review, searching for information on abiotic and biotic elements, including: soil characteristics, climatic conditions, altitude, and vegetation (Table 1). Subsequently, a site analysis was carried out to record the conditions of the land, the different natural and artificial elements that make up the landscape (including an inventory and identification of the trees and orchids), and the various points

Table 1. Study site characteristics, Ixtaczoquitlán, Veracruz, México.

Vegetation	Soil	Clima	Temperatura media anual	Precipitación anual	Altura
Cloud Forest	Vertisol crómico (CONABIO, 1995)	Semicálido húmedo, con lluvias en verano (García, 2004)	17 °C (García, 2004)	1,977 mm (García, 2004)	1,160 msnm

Table 2. Tree inventory, orchid species and study site attractions, Ixtaczoquitlán, Veracruz, México.

Species/Atractive	Common name
Trees	
Ficus sp.	Higuera
Eriobotrya japonica (Thunb.) Lindl.	Níspero
Heliocarpus appendiculatus Turcz	Jonote
Bursera simaruba (L.) Sarg.	Mulato tree
Spondias sp.	Mexican ciruela
Orchids	
Isochilus linearis (Jacq.) R.Br.	
Prosthechea ochracea (Lindl.) W.E. Higgins	
Maxillaria densa (Lindl.)	
Site atractives	
Water spring "Cascada de la Calavera"	
Matzinga river tributary stream	
Water pond	
Lookout	
Greenhouses	
In vitro culture laboratoty	

of interest (Table 2). The company's characteristics were also described, based on three surveys with a Garmin® Etrex10 GPS device, obtaining the coordinates of the site, the altitude, and the paths. Finally, the area of the land was calculated.

The polygon was measured and the tree cover was calculated. The coordinates determined during the visits were used to generate a polygon with the Google Earth Pro software, in order to obtain the total area of the land. To calculate tree cover, the polygon tool was applied to a satellite image of the plot. Finally, the difference between both areas was calculated using the rule of three (Cecato *et al.*, 2020) and the information collected and the photographic record were integrated.

Study site

The study site is located in the municipality of Ixtaczoquitlán, in the state of Veracruz, Mexico, between 18° 50' 21" and 18° 50' 26" N and between 97° 04' 34" and 97° 04' 39" W. Its south border is a tributary stream of the Matzinga River, part of the Papaloapan River basin; to the North, its limit is the Privada de la Calavera Street and several chayote crops; to the East, it borders with chayote crops; and finally an uncultivated land lies to the West. The total area is 12,380 m^2 and has a perimeter of 563 m (Figure 1).

The participating company is also located in the municipality of Ixtaczoquitlán, in Veracruz, Mexico. It produces and commercializes *in vitro* and potted orchids; additionally, it sells pots and cultivation supplies. The company sells hybrids of the genera *Phalaenopsis*,

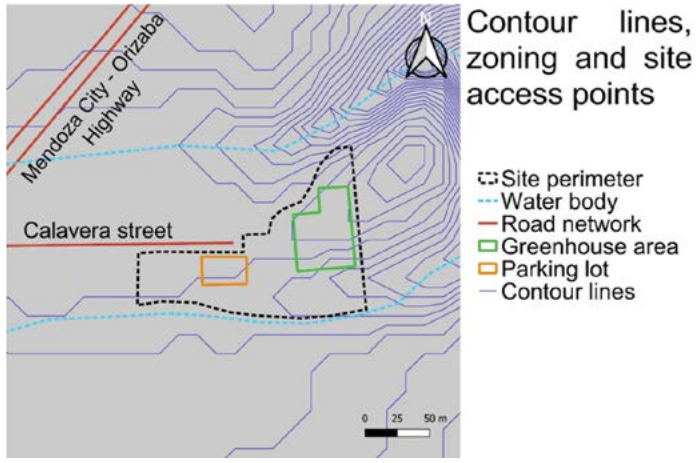

Figure 1. Study area, Ixtaczoquitlán, Veracruz, Mexico.

Cattleya, and *Dendrobium*. Its facilities include greenhouses, an *in vitro* culture laboratory, a recreational area, a tributary stream of the Matzinga River, a spring, and a pond. In addition, it has a Wildlife Conservation Management Unit (UMA), which provides the legal framework for the commercialization of native orchid species included in NOM-059-SEMARNAT-2010.

Second phase: Design and construction of the trail

Based on the methodology proposed by Baltazar-Bernal *et al*. (2014) —which takes into account site information, like inventory of trees and orchids, and the attractive features of the site—, different points of interest identified during the visits were chosen, including: active constructions, trees, paths, river, spring, and pond, as well as the physiography of the plot. The opinions and suggestions of the company's technicians were also considered. During the verification visit, the tree cover in most of the plot was calculated at 16-30%. Consequently, a zoning-based planting was the chosen option, since most orchids require shade to thrive (Morales-Linares and Menchaca-García, 2021).

Native tree planting

After carrying out the diagnosis of the place, a planting scheme was designed to increase the tree cover, vegetation cover, and green areas. Different species of native trees and those produced in regional nurseries were chosen for reforestation. Since most orchids are epiphytes, phorophytes were planted to increase plant coverage. Reforestations efforts were carried out at different points of the trail without or with scarce tree vegetation (Figure 2).

Trees were planted in the first days of July to coincide with the rainy season (Figure 3). Sixty-two trees were planted 8 to 10 m apart from each other (Table 3). It will take several years before the transplanted trees can be used as phorophytes; in the meantime, some other fast-growing plants could be used.

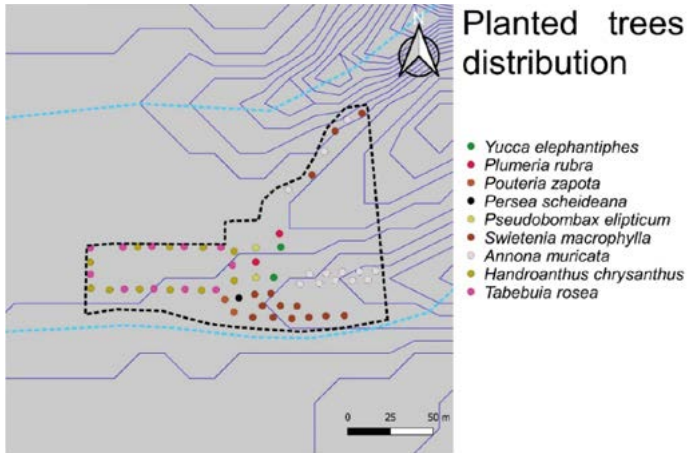

Figure 2. Trees planted in the study area, Ixtaczoquitlán, Veracruz, Mexico.

Figure 3. Tree planting in the study area, Ixtaczoquitlán, Veracruz, Mexico, A) *Tabebuia chrysantha* (Jacq.) G. Nicholson, B) *Tabebuia rosea* (Bertol.) DC., C) *Persea schiedeana* Nees, and D) *Annona muricata* L.

Plot zoning

Parking area

At the main entrance to the property, 20 trees of the species *Tabebuia mexicana* (Bertol.) DC and *Tabebuia chrysantha* (Jacq.) G. Nicholson were planted, 6 to 8 m apart from each other. These colorful trees will provide shade for vehicles.

Table 3. Tree species planted on the study site, Ixtaczoquitlán, Veracruz, México.

Scientific name	Common name	No.	Zones
Tabebuia rosea (Bertol.) DC.	Five leaves	12	1
Swietenia macrophylla King in Hook.	Caoba	15	3
Annona muricata L.	Guanábana	16	2
Tabebuia crhysantha (Jacq.) G.Nicholson	Primavera	12	1
Plumeria rubra L.	Plumería	2	2
Yucca elephantipes Lem.	Izote	2	1
Persea schiedeana Nees	Chinene	1	2
Pseudobombax elipticum (Kunth) Dugand	Lele	2	2
Total		62	

Hillside area

In this area, 10 *Annona muricata* L. trees and two *Persea* spp. were planted 8 m apart from each other. These tree species have strong roots that will maintain soil stability and atmospheric moisture. These conditions will allow the establishment of orchid species. While those trees grow, bamboo, a fast-growing species, could be planted.

River bank area

The flow of water that runs through the plot is important, since it provides a constant source of atmospheric moisture and is used to irrigate greenhouses. In this area, trees that commonly grow on river banks will prevent water erosion and maintain the humidity and temperature required by the orchids. Twenty *Swietenia macrophylla* King in Hook were planted 10 m apart from each other (Figure 4).

RESULTS AND DISCUSSION

Trail design

After the planting, the trail was designed at the company facilities, with the aim of raising awareness about the ecological importance of orchids and promoting the different species

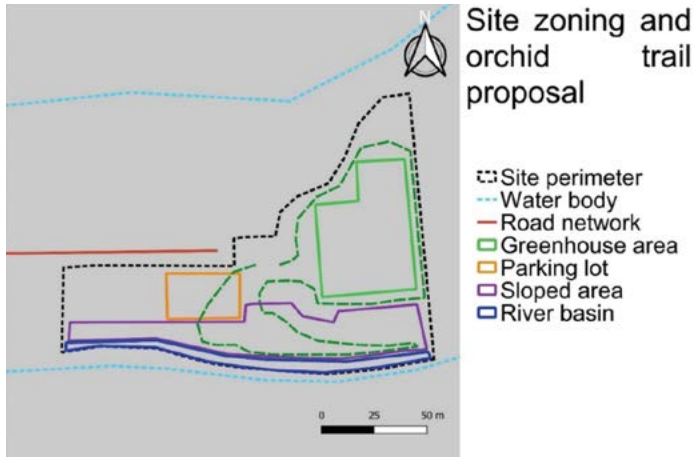

Figure 4. Lot zoning in Ixtaczoquitlán, Veracruz, Mexico.

that the company sells. With the information collected during the visits, the trail proposal was developed, using the pre-existing paths. The trail design included seven stations, where visitors will be able to observe some native orchid species and their phorophytes (Figure 5).

Stations

***Inicio / bienvenida* (*Start / Welcome*)**

Visitors will be welcomed at this point. They will be given an introduction about the diversity of orchids in the region (Krömer *et al.*, 2021) and their ecological importance, as one of the largest families in the world, which includes more than 30,000 species (Hágsater *et al.*, 2015; Solano-Gómez 2019). Species of orchids that tolerate sunlight exposure, such as *Myrmecophyla grandiflora* (Lindl.) Carnevali, J.L.Tapia and I.Ramírez, *Cyrtopodium macrobulbon* (Lex.) G.A., Romero-González and Carnevali, *Oncidium sphacelatum* Lindl., and *Catasetum intergerrimum* Hook may be used in this part of the path. Orchids can be grown in adult trees of *Ficus* sp., and *Eriobotrya japonica* (Thunb.) Lindl. (loquat). In few years in *Tabebuia rosea* (Bertol.) DC. and *Tabebuia chrysantha* (Jacq.) G. Nicholson recently planted. The importance of having a similar vegetation cover than in the forest (humidity, shade, and temperature) must be emphasized to establish and conserve the orchids that will be suggested for each station of the trail.

***Higuera* (*Ficus tree*)**

At this point, the importance of tall adult trees for the natural reproduction of orchids will be explained (Hernández-García *et al.*, 2021). The *Ficus* sp. (fig tree) tree will be pointed out as an example of a phorophyte, since several epiphytes are housed in its mature bark and it also provides shade (Figure 6A) (Hernández-Pérez *et al.*, 2018; Izuddin *et al.*, 2018). These characteristics of the *Ficus* sp. allow native species such as *Isochilus* sp. and *Prosthechea ochracea* (Lindl.) W.E. Higgins to inhabit it. This station can feature species that are resistant to dry conditions or that require less shade, such as: *Laelia anceps* Lindl., *Oncidium sphacelatum* Lindl., and *Epidendrum melistagum* Hágsater.

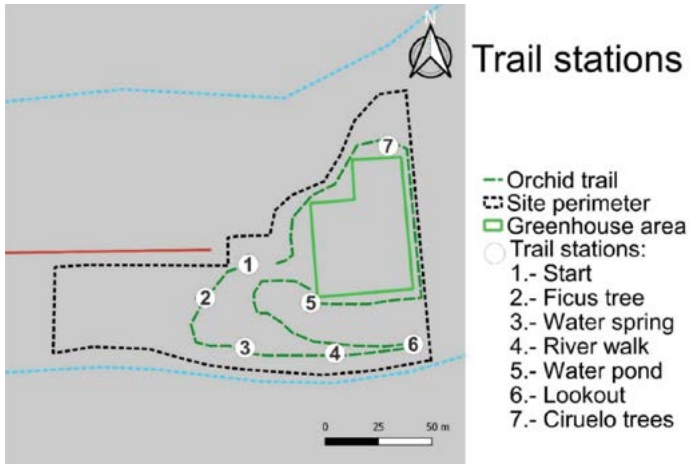

Figure 5. Design of the trail and its stations in a company in Ixtaczoquitlán, Veracruz, Mexico.

Figure 6. Stations of the trail: A) La Higuera, B) El Manantial, C) El Río, D) El Estanque, E) El Mirador, and F) Los Ciruelos.

***Manantial* (*Water spring*)**

This station offers a view of the beautiful, crystal-clear water spring "Cascada de la Calavera;" the overall importance of water bodies and their positive influence on orchids and flora will be explained at this point in the path. The role that environmental moisture plays in the development and maintenance of orchid populations will also be explained. Emphasis will be made on the risk that orchid populations face as a result of the reduction of moisture and decrease of the shade provided by the trees (Anastacio-Martínez *et al.*, 2016; 2019; Solano-Gómez *et al.*, 2019). Although this station will not include any phorophytes suitable for the adaptation of epiphytes, the walls of the spring can house species that require a lot of environmental moisture, such as *Epidendrum parkinsonianum* Hook and *Erycina pusilla* (L.) N.H.Williams & M.W.Chase. The area features adult *Bursera simaruba* (L.) Sarg. (gumbo limbo) trees; however, orchids are not able to anchor on their slippery and constantly renewing bark. Therefore, species such as *Pouteria sapota* (Jacq.) H.E.Moore & Stearn (Figure 6B) and *Persea scheideana* were established.

***Camino del río* (*River walk*)**

In this part of the trail, visitors will be told that most orchids prefer to live on trees located in river banks, because the greater abundance of vegetation cover protects them better (Hernández-Pérez *et al.*, 2018; Morales-Linares and Menchaca-García, 2021). Consequently, more than 60 trees were planted on the trail. In adult trees of

Heliocarpus appendiculatus Turcz (Figure 6C), orchids such as *Myrmecophyla grandiflora* Lindl. Carnevali, J.L.Tapia & I. Ramírez, *Laelia anceps* Lindl., and *Oncidium sphacelatum* Lindl will be stablished.

Estanque (*Water pond*)

This station is halfway along the path and has an area with a palm-roof palapa, where visitors can rest and relax. The great hydrological wealth of the state of Veracruz and the importance of Pico de Orizaba as a water source for the entire region will be explained (Rivera-Hernández *et al.*, 2019). Furthermore, the importance of water bodies (Figure 6D) —which help to maintain environmental moisture— for the development of native orchids will be highlighted: moisture explains the great diversity of orchids in the cloud forest (Hágsater *et al.*, 2015). The native species suggested for this area include *Oncidium sphacelatum* Lindl, *Laelia anceps* Lindl., *Heliocarpus appendiculatus* Turcz., and *Chamaedorea tepejilote* Liebm.

Mirador (*The Viewpoint*)

At this station, visitors will be invited to the commercial orchid exhibition area. The viewpoint should be rearranged to allow visitors to enjoy the view. The *in vitro* cultivation processes, acclimatization, hardening of orchid plants for commercialization, and the care they require will be explained (Chen *et al.*, 2020), especially those of native species (Krömer *et al.*, 2021). Once the *Plumeria rubra* L., *Pseudobombax elipticum* (Kunth) Dugand, and Yucca elephantipes Lem species (Figure 6E) reach their adult stage and provide vegetation cover, *Oncidium sphacelatum* Lindl. can be established.

***Ciruelos mexicanos* (*The Mexican plums*)**

Several adult Mexican plum trees (*Spondias* sp.) can be found in this station. They host such orchids as *Isochilus linearis* (Jacq.) R.Br., *Prosthechea ochracea* (Lindl.) W.E.Higgins, and *Maxillaria dense* (Lindl.). The importance of native trees as hosts of orchids will be emphasized at this point (Hernández-García *et al.*, 2021); orchids will be admired along the trail (Lucero *et al.*, 2021; Hernández-Pérez *et al.*, 2019; Hernández-Pérez *et al.*, 2018). In addition, visitors will be invited to establish epiphytic orchids on some trees with the following procedure: orchid plants with four pseudobulbs will be attached to the trunk of the phorophyte with a cotton thread, at a height of 1.2 to 2.0 m. (Hernández-García *et al.*, 2021) (Figure 6F). At this point, the conclusions will also be given.

The walk through the 420-m long orchid conservation trail in Ixtaczoquitlán, Veracruz, lasts 90 minutes. It has been designed for the public interested in learning about the orchids that grow in their phorophytes. Although it does not have access and infrastructure for people with disabilities, it is relatively accessible for seniors and children, which makes it a family-friendly site. Its operation is a work in progress and it will take from 6 to 10 years, before the trees that were established can house orchids and provide greater vegetation cover. However, given the appeal of the place and, if the plot is properly prepared, visits can be made to validate the trail, before it is opened to the public.

CONCLUSIONS

The orchid trail designed for the company requires greater plant coverage to establish and conserve the suggested orchids at each station of the trail, which is why 62 native trees that develop in the region as orchid phorophytes were planted.

The trail is in an anthropized area with low tree cover, therefore, it will take between six and ten years to be consolidated. However, it is recommended to validate the design of the trail, so that in the medium term it can be used to raise awareness about the ecological importance of orchids, and promote the species they produce.

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