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The importance of forests in the conservation and prevalence of orchids in *Megamexico*

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ABSTRACT

Objective: To describe the threats to forests and the repercussions that these imply for the maintenance and conservation of orchids in their natural habitat.

Design/Methodology/Approach: A comprehensive reference search on orchids and their habitats was performed. The physiological and morphological characteristics of orchids in *Megamexico* are described according to their life forms; additionally, the way in which these adaptations respond to the environment in which they thrive is explained. In this regard, threats to orchids and forests are listed. Therefore, emphasis is placed on the implications that habitat loss would have for the prevalence of many orchid species in this biogeographical region.

Results: The humid forests of the mountain ranges of *Megamexico* host an impressive orchid richness, where there are far more epiphytic life forms than terrestrial ones. However, these ecosystems face a major threat from anthropogenic activities. As a result of the constant threats faced by forests —such as deforestation, arsons, land use change, etc.—, epiphytic orchids are the most threatened species, due to the loss of their habitat and the ecological requirements they need to survive.

Study Limitations/Implications: This study describes the threats to many orchid species as a result of habitat loss and illegal looting.

Findings/Conclusions: Forest conservation is vital for orchid maintenance and conservation because genetic diversity and ecological interactions among orchid species and other organisms are maintained.

Keywords: Orchidaceae, epiphytes, conservation, *Megamexico*.

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INTRODUCTION

Megamexico is a defined biogeographical region based on the geographic affinities and the endemism of the phanerogamic flora of Mexico. It stretches from the Sonoran, Chihuahuan, and Tamaulipan deserts in northern Mexico, and the southern United States of America, to central and northern Nicaragua (Rzedowski, 1991). This region stands out in the world for its complex geological history (Ferrusquía-Villafranca, 1998), its rugged topography (Mastretta-Yanes *et al.*, 2015), and its climatic heterogeneity; these characteristics encourage the presence of almost all types of world vegetation (Rzedowski, 1991).

Therefore, tropical evergreen forest (TEF), tropical sub-deciduous forest, tropical deciduous forest, thorn forest, xeric shrubland, grassland, oak forest, coniferous forest, mountain mesophyll forest (MMF) and aquatic and sub-aquatic vegetation are found in this biogeographic region (Rzedowski, 1991) (Figure 1). The presence of these types of vegetation favors the presence of a great diversity of flora and fauna species.

IMPORTANCE OF ORCHIDS IN *MEGAMEXICO*

Orchidaceae is one of the most diverse groups of plants in *Megamexico* (Villaseñor, 2016). Undoubtedly, orchids are one of the more charismatic and striking families of flowering plants (Figure 2). They belong to the most diverse family of angiosperms and they have the greatest morphological variation (Christenhusz and Byng, 2016). This group of plants encompasses about 30,000 species, grouped in 736 to 880 genera (Givnish *et al.*, 2015).

Orchids have complex physiology and morphology which have allowed them to adapt to the forests where they live. Based on their life form, there are terrestrial, lithophyte (growing on rocks), and epiphytic (growing on trees without causing a negative effect) species. Particularly, epiphytes show CAM photosynthesis; meanwhile, most of the terrestrial species are C3. All orchids develop small, powder-like seeds. The roots of

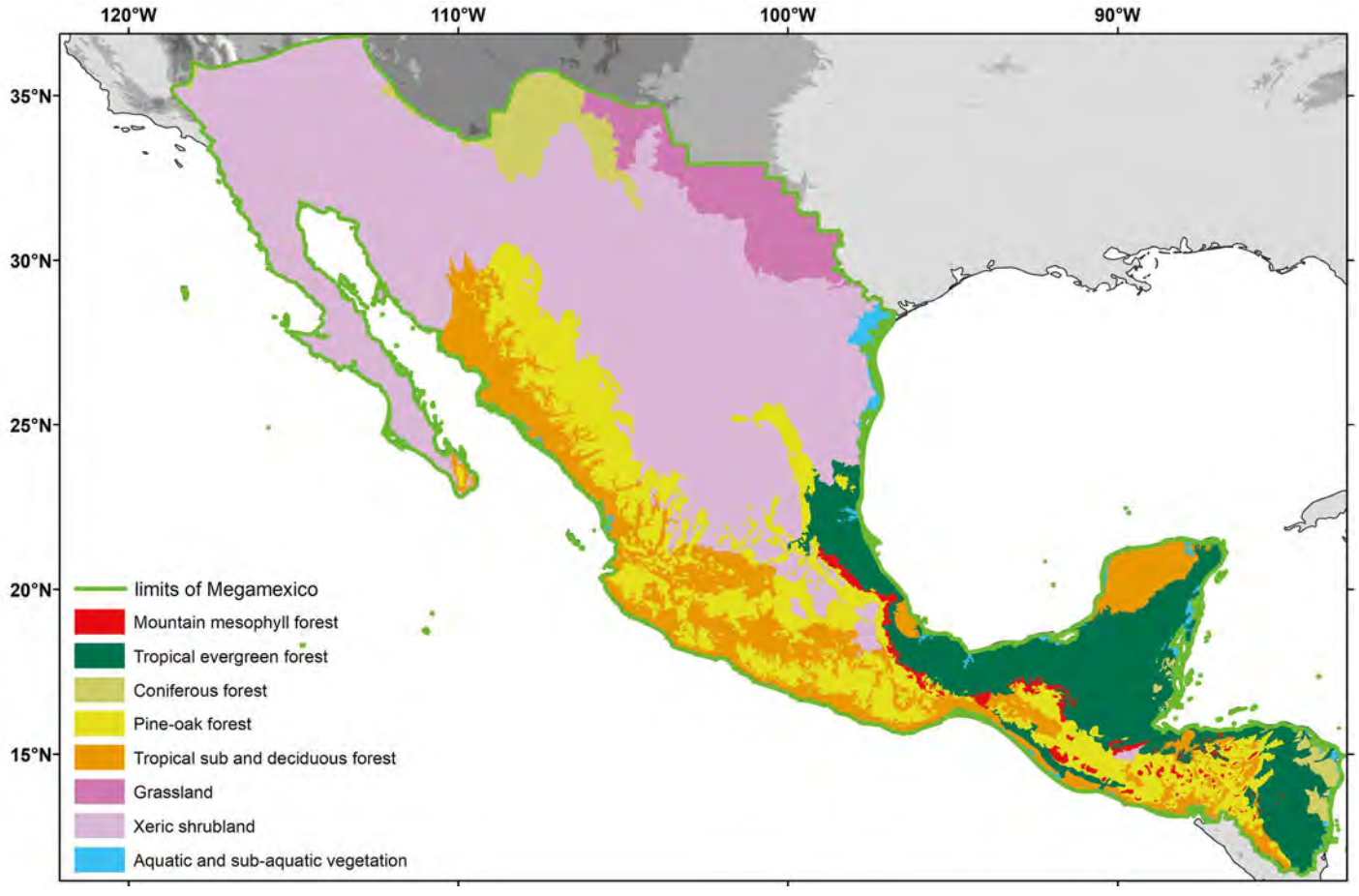

Figure 1. Types of vegetation found in *Megamexico*.

Figure 2. Orchid diversity in the mountain mesophyll forest (MMF) and tropical evergreen forest (TEF).

epiphytes develop a velamen, a special tissue that allows them to absorb water from the environment. These characteristics are a response to their eco-physiological adaptations, such as the range of light tolerance, temperature, and humidity (Krömer *et al.*, 2007). According to Benzing (1990), epiphytism, along with CAM photosynthesis, is the result of a set of adaptations developed to survive the conditions of the canopy. This has favored their expansion in the forest canopy, especially in the case of tropical forest orchids living in humid environments.

The great diversity of orchids is given by their ability to occupy a wide range of ecological niches (Ricklefs and Renner, 1994), their association with specific pollinators, and their dispersing capabilities (Tremblay, 1992; Jersáková *et al.*, 2006). Consequently, these factors have promoted their diversification and reduced their vulnerability to extinction (Ricklefs and Renner, 1994).

Gutiérrez-Rodríguez *et al.* (2022) reported 1,732 orchid species in *Megamexico*, which are taxonomically grouped into 189 genera, 36 subtribes, and 17 tribes. From this number, 982

species are endemic —*i.e.*, just over 50% are exclusive to this region, making it an important area for orchid diversity. Seventy percent of orchids (1,226 species) are epiphytes, while the remaining are terrestrial. The most diverse areas (characterized by a high degree of orchid endemism) are located in the humid forests of the mountain ranges of southeastern Mexico, central Guatemala, and central Nicaragua. In these areas, epiphytes were considerably more abundant than terrestrial species (Gutiérrez–Rodríguez *et al.*, 2022).

Terrestrial orchids thrive best in environments with clearly defined seasonality. For example, they usually comprise most of the orchid flora of oak forest, and pine-oak forests, as well as of sub and tropical deciduous forests. This type of vegetation is common in the north, center, and west of *Megamexico*, as well as in some parts of the south of this region. By contrast, an abundant presence of epiphytes is encouraged in forests where humidity is extremely high. This type of forest is located in the central-southern and southeastern *Megamexico*, as well as in high elevations of the main mountain systems.

Threats to orchids

The flower is the most attractive part of orchids (Van Der Pijl and Dodson, 1966). Their beauty and the amazing morphological variation of their flowers have attracted the attention of scientists, botanists, growers, and nature photographers. However, many species are sought, looted, and trafficked by sellers, collectors, and people in general (Espejo-Serna *et al.*, 2002) (Figure 3). Compared to other plant families, orchid species face many threats

Figure 3. Orchids face several threats, including trafficking and illegal sale.

(both natural and of human origin). Orchids are one of the most illegally trafficked and most vulnerable groups in *Megamexico* and around the world. In the countries that make up *Megamexico*, orchids figure prominently on many of the threatened species lists. For example, 188 species are included in the Mexican NOM-059-SEMARNAT endangered species list (SEMARNAT, 2010). Hágsater and Soto-Arenas (1998), Kull *et al.* (2006), García-Franco (2018), and many others have reported that the abundance of various species has been decreasing to critical levels in recent decades. In addition, many species are used for ornamental purposes. Furthermore, some species have economic value; such is the case of *Vanilla*, used as a flavoring around the world.

The Environmental Management Units (EMUs) have been a viable and sustainable method for the conservation of many orchids. Nevertheless, it has not been convenient for many others, because it is almost impossible to recreate the ecological conditions found in their natural habitats. This is particularly true about those orchids that have a symbiotic relationship with fungi and depend on them to survive. The same phenomenon takes place with those species that serve as a home for other organisms (*e.g.*, *Myrmecophila* Rolfe and *Caularthron* Raf.) and that benefit from them, protecting these orchids from defoliators. Others depend on anthills to germinate, such as *Epidendrum flexuosum* G. Mey. and *Coryanthes picturata* Rchb. f.

Epiphytic orchids are in serious risk of extinction

Different orchid groups have different resilience levels (Kull *et al.*, 2006). Some of the species are more resistant to disturbance than others. Particularly, some terrestrial orchids seem to be favored by these disturbances, like some of the species belonging to the *Bletia* Ruiz & Pav. genus which are commonly found on the roadsides. Somehow, terrestrial orchids —such as *Dichromanthus aurantiacus* (Lex.) Salazar & Soto Arenas— are not as threatened as epiphytes: they can survive the disturbance and even colonize degraded areas like pastures. By contrast, some *Habenaria* Willd and *Lepanthes* Sw. species do not tolerate these disturbances and are highly susceptible to changes.

THE ROLE OF FORESTS IN THE MAINTENANCE OF ORCHIDS

Cloud immersion, vast water availability, and shade in mountain habitats provide favorable microclimates for the prevalence of epiphytic orchids (Gutiérrez-Rodríguez *et al.*, 2022). Epiphytic orchids are at the highest risk of extinction, because the environments in which they thrive are being destroyed.

MMF are the most threatened ecosystems (Challenger, 1998; Morales and Armenteras, 2013; Téllez-Velasco and Tejeda-Sartorius, 2017), followed by TEF (Gómez-Pompa *et al.*, 1972). These forests are vitally important, due to the extraordinary biodiversity they house (Challenger, 1998) (Figure 4). Particularly, these ecosystems have the greatest orchid diversity, especially of epiphytes. This abundance is the result of a simple phenomenon: the total area of treetops in tropical forests is considerably larger than the ground area. Therefore, the niche available for plants is greater (Gravendeel *et al.*, 2004). Hernández-Pérez *et al.* (2017) have shown that tree height can impact epiphyte abundance, richness, and diversity. In the same way, De Andrade-Kersten *et al.* (2009) have proven that the

Figure 4. Tropical evergreen forest (left) and mountain mesophyll forest (right) are the ecosystems with more orchid species.

greatest epiphytes diversity is found in the medium-superior strata of trees, especially in the branches (García-González *et al*., 2021).

TEF distribution matches the high rainfall areas of *Megamexico* and is one of the most exuberant ecosystems. TEF structure consists of one herbaceous, one shrub, and two arboreal strata. Epiphytes and lianas are very abundant (Challenger, 1998). Meanwhile, MMF is the ecosystem which covers the smallest area (Mullingan and Burke, 2005). Although its area is so small, it is home to a greater diversity of flora and fauna species per surface unit (Rzedowski, 1978; Challenger, 1998; CONABIO, 2010). This type of ecosystem is immersed in clouds that cover the vegetation (Hamilton *et al*., 1995). The persistence of this forest depends on relatively high humidity, rugged topography, soil with a high amount of organic matter, and a temperate climate (Velázquez *et al*., 2000). The MMF structure is formed by canopy trees, sub-canopy trees, lianas, arborescent ferns, shrub stratum, climbing plants, epiphytes, and saprophytes.

THREATS TO FORESTS

Forests are home to a large number of plants. However, forests are threatened by several factors, most of them related to anthropogenic causes. For example, some of the major threats reported by CONABIO (2010) include: deforestation, illegal logging, livestock, agriculture, climate change, droughts, fragmentation, road construction, arson, and urban areas expansion.

Nowadays, MMF and TEF face extreme threats on multiple fronts, including: change in land use; transformation of lower areas into agroecosystems (*e.g*., coffee plantations), livestock, urban expansion, fragmentation, creation of roads, illegal selective logging, and natural resources overexploitation. Vegetation is almost impossible to regenerate when forests are felled, and/or fragmented, because environmental conditions change drastically. Consequently, these ecosystems are impossible to restore (Gómez-Pompa *et al*., 1972; García-Franco, 2018).

Climate change also poses serious problems for orchid prevalence and conservation, as well as for MMF (Foster, 2001; CONABIO, 2010). This phenomenon has had implications

for hydrological processes affecting precipitation patterns and cloud abundance (Foster, 2001). The absence of clouds in the MMF is a result of the decrease in cloud formation and evapotranspiration. Consequently, vegetation is no longer immersed in clouds and there is not enough humidity to maintain species that require high humidity levels. This situation leads to local extinctions (Foster, 2001).

If we consider all the threats faced by these forests, the scene is discouraging. Fires and excessive logging devastate the trees, which fulfill many functions, including being the orchids' habitat; consequently, orchid flora is also destroyed. A similar situation has been reported with the increased mortality of epiphytic orchids, as a result of branches falling and the death of old trees (Kull *et al.*, 2006).

Despite their great numbers, the conservation of orchids living in these types of ecosystems faces an enormous challenge. The loss and transformation of forests compromise orchids growing there. Also, given the noticeable lack of protected natural areas in these ecosystems, taking care of them is a priority. Menchaca *et al.* (2012) proposed an alternative to meet this suggestion; they recommend recognizing orchids as a non-timber forest resource that can also be used by rural communities.

CONCLUSIONS

Forests not only house a high level of biodiversity, but also provide vital habitats for many species, especially epiphytic orchids. For many reasons, some types of orchids cannot grow on disturbed sites or in *ex situ* conditions and, therefore, cannot be cultivated. While *ex situ* conservation and tissue culture are a feasible alternative for many species, forest conservation is essential for the maintenance of orchids; consequently, an uninterrupted gene flow between *in situ* populations allows genetic variation. Also, it enables orchids to maintain their interactions with other organisms. Many authors have reached this conclusion (*e. g.*, Hágsater *et al.*, 2005; Tejeda-Sartorius *et al.*, 2017).

Orchids play an important role in water intake and nutrient recycling (García-Franco and Toledo-Aceves, 2008). In addition, their absence in these ecosystems would entail an unprecedented biodiversity loss which would affect all the species that interact with orchids —for example, the wide range of their pollinators, etc.

It is clear that, in the best-preserved areas, there is a greater diversity and abundance of species. However, in highly disturbed forest areas, this diversity and abundance are much lower and even orchids may be absent. We must raise awareness and motivation about taking care of our natural resources, because, if the forests disappear, orchids will follow. Ultimately, if any of the endemic orchid species of our study area disappears, it will not only disappear from *Megamexico*, but it will also disappear from the planet. Its lineage would be lost forever.

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