






DEFICIENCIES IN COMPLIANCE WITH ENVIRONMENTAL REGULATION FOR ORCHID
TRADE VIA SOCIAL NETWORKS IN MEXICO
DEFICIENCIAS EN EL CUMPLIMIENTO DE LA REGULACIÓN AMBIENTAL PARA EL COMERCIO DE
ORQUÍDEAS VIA REDES SOCIALES EN MÉXICO

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Abstract

Background: Online commerce (e-commerce) includes wild orchids, but it may constitute illicit trade and a risk for its conservation. In Mexico, the magnitude of this e-commerce, if it shows to be illicit, and how environmental crimes are constituted according to the country's regulations are unknown.

Questions: How many orchid species are offered in e-commerce? Where do the offers originate? Does this trade become a scenario for environmental crimes? What differences are there in the seller profile and earnings between e-commerce and traditional markets?

Studied species: Orchids commercialized in social networks of Mexico.

Study site and dates: Mexican states with orchid e-commerce, October-December 2020.

Methods: Three e-commerce platforms were reviewed, documenting species richness, active sellers, points of sale and verifying compliance with environmental regulations. We compared the orchid richness and prices in e-commerce with those registered in traditional markets in Mexico.

Results: We registered 344 publications, 164 orchid taxa, half Mexican native and 39 hybrids. These offers do not always originate in areas of high orchid richness. In Mexico, orchid management for commercial purposes requires registration and consent of the environmental authority, but no seller has provided evidence regarding it. Prices are higher in e-commerce than in traditional markets.

Conclusions: e-commerce offers orchid varieties (native, nonnative, hybrid) and traditional markets only native. Because in e-commerce sellers do not provide evidence of compliance with the environmental regulations, the digital platforms prompt environmental crimes.

Key words: Illicit wildlife traffic, Mexican environmental regulations, ornamental plants, sustainable wildlife management, threatened species.

Resumen

Antecedentes: El comercio en línea (e-comercio) incluye orquídeas, pero esto podría constituir un actividad ilícita y un riesgo para su conservación. En México se desconoce la magnitud de este e-comercio, si muestra ser ilícito, y cómo se constituyen delitos ambientales de acuerdo a la normatividad del país.

Preguntas: ¿Qué cantidad de orquídeas se ofertan en el e-comercio? ¿Dónde se originan las ofertas? ¿Este comercio es escenario de crímenes ambientales? ¿Qué diferencias hay en el perfil y ganancias del vendedor entre e-comercio y mercados tradicionales?

Especies de estudio: Orquídeas comercializadas en redes sociales de México.

Sitio y años de estudio: Estados mexicanos con e-comercio de orquídeas, octubre-diciembre 2020.

Métodos: Revisamos tres plataformas de e-comercio, documentando cantidad de orquídeas, vendedores activos, lugares de venta y verificando el cumplimiento de la normatividad ambiental. Comparamos cantidad y precios entre e-comercio y mercados tradicionales de México.

Resultados: Registramos 344 ofertas y 164 orquídeas, la mitad nativas de México y 39 híbridos. Las ofertas no siempre provienen de áreas con alta riqueza orquídeológica. El manejo de orquídeas con fines comerciales requiere registro y permisos ante autoridades ambientales, pero los vendedores no presentaron evidencias de ello. Los precios son más altos en el e-comercio que en mercados tradicionales.

Conclusiones: El e-comercio ofrece variedad de orquídeas (nativas, no-nativas, híbridos) y los mercados tradicionales solo nativas. Como los vendedores no proporcionaron evidencias de cumplir la normatividad ambiental, las plataformas digitales promueven delitos ambientales.

Palabras clave: Especies amenazadas, manejo de vida silvestre, normatividad ambiental mexicana, plantas ornamentales, tráfico ilícito de vida silvestre.

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Management of the Mexican wild flora, including that for commercial purposes, is determined by regulations that integrate several legal instruments. Mexico's Federal Criminal Code (CPFM 2020) considers a section on environmental crimes, as the article 420 punishes illegal activities related to trafficking, transporting or extracting specimens of endemic, endangered or wild species, or those regulated by international agreements to which Mexico subscribes. As many of the plant species of this country are included in the Convention on International Trade of Endangered Species (CITES), to which Mexico subscribes, developing any of these activities illegally constitutes an environmental crime. Other Mexican legal instruments are the General Wildlife Law (LGVS) (SEMARNAT 2018a), General Law on Sustainable Forest Development (LGDFS) (SEMARNAT 2018b), and General Law on Ecological Balance and the Environmental Protection (LGEEPA) (PROFEPA 2016).

According with LGVS, the extractive and nonextractive use of wild flora requires the authorization of the Ministry of Environment and Natural Resources (SEMARNAT). For species managed outside their natural habitats, SEMARNAT must verify its legal provenance. LGEEPA establishes that sustainable use of wild flora requires permission of SEMARNAT and seeks to combat illegal species trafficking. The LGDFS states that authorization is required for the management of timber and nontimber resources from forest ecosystems. The guidelines for the management of nontimber forest resources are specified in NOM-005-SEMARNAT-1997 (SEMARNAT 1996), while NOM-059-SEMARNAT-2010 (SEMARNAT 2019) includes the list of wild flora at risk whose management requires authorization of SEMARNAT.

Mexican orchids include over 1,300 species and 168 genera (Solano-Gómez *et al.* 2019, 2020), from which 192 species are at risk (SEMARNAT 2019) due to deforestation, land use change, intrinsic biological problems, climate change and extraction for illicit trade (Solano 2021, Soto-Arenas *et al.* 2007). The trade of wild orchids in traditional markets generates economic profits for sellers, but this practice does not always reduce poverty (Joaquín-Casino 2001, Reuter 2009, Stanley *et al.* 2012). Furthermore, wild specimens are extracted without legal authorization (Flores-Palacios & Valencia-Díaz 2007, Martínez-Gómez 2014, Cruz-García *et al.* 2015, Molina-Luna *et al.* 2015, Emeterio-Lara *et al.* 2016, Jiménez-López *et al.* 2019a, b). However, Mexican wild orchids, as part of the biological heritage of the country, can be managed within a legal framework as they are considered an environmental asset for low-income communities in the attempt to produce sustainable biodiversity economy (Dasgupta 2017). If biodiversity generates environmental goods and services, there must be limits to its commercialization to guarantee its conservation. However, distinguishing between items susceptible to commercialization and those that must be protected is not simple. Markets must have ethical limits when trading biodiversity and they should not be trivialized or patented (Tirole 2017). However, these limits are hard of defining in biodiversity markets. For example, threatened orchids should be protected, but they can be propagated for commercial purposes without following any regulations.

With the development and expansion of social networks, orchid sales have adapted to online commerce (e-commerce) and orchid hobbyists now use these online platforms to offer and purchase orchids. Sellers benefit from anonymity (Grabosky 2013) and can reach a large number of potential customers (van Heck 2021), having more efficient sales and expanding the market (Lavorgna 2014). Buyers then have two markets for acquiring orchids, including the traditional market and online platforms, but they do not necessary substitute each other. Buyers distinguish between specimens offered in each market and make choices based on the traits of species, rarity, flower color, geographic origin, flower span life, age, size and, overall, the health of the specimen.

Orchid e-commerce has recently moved from Asia to United States and Europe. Studies have reported that it can operate illegality and become a scenario for environmental crimes (Hinsley *et al.* 2016a, 2018). Some platforms identify the location of the buyer and can block the transaction, aiding with CITES compliances, but it is rare (Wong & Liu 2019). Up to 25 % of people involved in the e-commerce of orchids from Asia to United States and Europe are engaged in smuggling, money laundering or importing specimens without CITES documentation (Hinsley *et al.* 2016a, b). Networks of sellers and buyers build platforms around a shared language and prefer wild orchids over cultivated ones (Hinsley *et al.* 2016b). Given the complexity of regulating and monitoring this e-commerce, as

compared with traditional markets, collaboration between governments, NGOs, scientists and platforms is required (Hinsley *et al.* 2016a, b, 2018, Wong & Liu 2019, Khabbach *et al.* 2022).

Trading wild orchids has become a common activity in social networks of Mexico and their commercial exploitation must comply with the environmental regulations. Otherwise, it becomes illicit wildlife traffic and platforms are scenarios of environmental crimes (Carpio-Domínguez *et al.* 2018). Considering these issues, we performed a first assessment of orchid e-commerce in Mexico addressing the following questions: (1) what is the number of orchids offered in e-commerce? (2) where do orchid offers originate in this country? (3) does e-commerce comply with Mexican environmental regulations? And (4) are there differences in the profiles and profits of sellers when e-commerce and traditional markets are compared?

Materials and methods

Sources of information. Information about orchid e-commerce was collected from October to December 2020 on three online platforms that operate in Mexico, including Compra Compras (www.compracompras.com/mx), Facebook Marketplace (www.facebook.com/marketplace) and Mercado Libre (www.mercadolibre.com.mx). In all cases, we used the keywords “orchid”, “orchids”, “orchids for sale” and “orchids on offer” in their search engines. The search in Compra Compras and Mercado Libre covered all Mexican states, but 80 % of publications are originated in the state of Veracruz. The remaining publications were from Chiapas, Chihuahua, Guerrero, Michoacan, Morelos, Oaxaca, Puebla, Tamaulipas, Tlaxcala, State of Mexico, and Mexico City. In Facebook Marketplace, the search covered a radius of 500 km around the city of Cordoba (state of Veracruz), covering Mexico City and the states of Guerrero, Hidalgo, Mexico, Morelos, Oaxaca, Puebla, Queretaro, Tlaxcala and Veracruz, as well as parts of the states of Chiapas, Guanajuato, Michoacan, San Luis Potosi, and Tabasco. Compared with the other two platforms, only Chihuahua was excluded from the search on Facebook Marketplace, while it included the possibility of registering publications from three additional states (Hidalgo, Guanajuato, and Queretaro). This allowed us knowing the orchids offered in online markets, what species are part of the national flora, whether their commercial exploitation follows the legal framework for management of native flora and identifying the guidelines to make it possible.

Species, origin of publications and sellers. The information gathered from the three platforms was the species name, origin (native to Mexico, nonnative, hybrid), risk category according to NOM-059-SEMARNAT-2010 (SEMARNAT 2019), platform where the orchid is offered, price of the offer and origin (state and city) of the offer. This information made possible knowing (i) the number of species and hybrids, (ii) number of publications offering orchids, (iii) the number of users that publish offers, and (iv) the geographic origin of offers. Sometimes, the same user published offers of the same species on more than one platform and, in these cases, offers were considered separate records and the user and the species were considered a single record. Publication consisted in an image of the offered orchid, which generally corresponded to complete individuals of a single species. Publications offering several species were treated as different registers for each species. We took care of checking for the same offer posted on different platforms to not include it as duplicate record. Scientific names of specimens were corroborated with Soto-Arenas *et al.* (2007) for orchids native to Mexico. For nonnative orchids and hybrids, we used the online websites of the American Orchid Society (www.aos.org/orchids/orchids-a-to-z.aspx), Epidendra (epidendra.com) and Orchidweb (www.orchidweb.com/orchids). Species names followed Solano *et al.* (2020) for Mexican orchids and for nonnative orchids and hybrids we used the name provided in the platforms mentioned above.

Comparison of e-commerce and traditional markets. The number and prices of orchids traded in the three platforms were compared with those reported in traditional markets from Xalapa, state of Veracruz (Flores-Palacios & Valencia-Díaz 2007), San Pedro and San Pablo Ayutla and Santa María Tlahuitoltepec, state of Oaxaca (Martínez-Gómez 2014), Tlaxiaco, state of Oaxaca (Cruz-García *et al.* 2015), State of Mexico (Emeterio-Lara *et al.* 2016), and Comitan and Las Margaritas, state of Chiapas (Jiménez-López *et al.* 2019a, b). We use these studies because they document

the number of orchids, prices, sales volumes and sale periods. Additionally, these studies report if orchid specimens were extracted from forests. For comparing the prices of orchids registered in traditional markets (between 2003 and 2016) and those reported in e-commerce (between October and December 2020), we performed the corresponding update. For this, we considered the procedure established in Articles 6 and 17-A of the Mexican Income Tax Law (CD 2021), which recognize variations due to time and inflation to homologate prices. The dates for calculating the price update factor were determined as shown in [Table 1](#).

Table 1. Summary of information obtained from the studies used in the estimation for the prices actualization factor among orchids traded in traditional markets and e-commerce. NP = information not provided in the study.

| Reference | Sample period | Species/sales volume | Method employed | Actualization factor date |
|---|------------------------------------|----------------------|---|---------------------------|
| ¹ Cruz-García <i>et al.</i> (2015) | September 2011 - August 2012 | 37/18,740 | Semi-structured interview, interview-buying | August 31, 2012 |
| ² Emeterio-Lara <i>et al.</i> (2016) | 2011 - 2013 | 6/359 | Structured interview, interview-buying | December 31, 2013 |
| ³ Flores-Palacios & Valencia-Díaz (2007) | 6 de July 6, 2001 - April 18, 2003 | 167 | Open interview, interview-buying | March 31, 2003 |
| ⁴ Jiménez-López <i>et al.</i> (2019a) | January - December 2014 | 28/NP | Structured interview, interview-buying | December 31, 2014 |
| ⁵ Jiménez-López <i>et al.</i> (2019b) | December 1 - 31, 2016 | 60/738 | Semi-structured interview, interview-buying | December 31, 2016 |
| ⁶ Martínez-Gómez (2014) | December 2013 - July 2014 | 9/441 | Open interview, interview-buying | July 31, 2014 |

For traditional markets, a socioeconomic profile of sellers was proposed according with the information provided by Cruz-García *et al.* (2015), Jiménez-López *et al.* (2019a), and Martínez-Gómez (2014). Parameters such as gender, age, schooling, knowledge of an original language and main line of work were considered for this profile. In social networks, as people who post orchid offers remain anonymous, it was not possible determining the socioeconomic profile of these sellers. For this reason, the socioeconomic profile of online sellers was inferred using information about the Mexican population that use social networks, which is included in the report on the use of information and communication technologies in Mexico of the Federal Institute of Telecommunications (IFT 2019).

Verification of compliance with environmental regulations in e-commerce. To verify whether e-commerce of Mexican orchids is performed legally, we reviewed (i) the user policies of online platforms and the lists of prohibited products, looking for statements about wild flora or indicating that the sale of wild species is against the law and (ii) user evidence documenting the legal provenance of specimens offered, looking for statements indicating whether they were not extracted from natural habitats and, if they are propagated, whether sellers have authorization for commercial management. The absence of evidence demonstrating compliance with the previous statements was considered an environmental crime. We also revised the Mexican environmental regulations of CPF, LGVS, LGEEPA, LGDFS and NOM-059- SEMARNAT-2010, and a set of guidelines was proposed to develop a conduct code that involves all parties of orchid e-commerce.

Results

Number of orchids present in e-commerce. Among the three platforms, publications offering 164 orchids were documented, from which 82 offer species native to Mexico (50 %), 43 offer nonnative species (26.2 %) and 39 offer hybrids (23.8 %) ([Supplementary material, Table S1](#)). Among the native orchids, 15 species are at risk according with NOM-059- SEMARNAT-2010, including *Chysis limminghei* Linden ex Rchb. f., *Clowesia rosea* Lindl., *Cuitlauzina pendula* Lex. *Encyclia adenocaula* (Lex.) Schltr., *Encyclia atrorubens* (Rolfe) Schltr., *Laelia dawsonii* (J. Anderson) Crawshay, *Laelia gouldiana* Rchb. f., *Laelia speciosa* (Kunth) Schltr., *Lycaste skinneri* Bateman, *Oncidium incurvum* Barker ex. Lindl., *Prosthechea citrina* (Lex.) W. E. Higgins, *Prosthechea karwinskii* (Mart.) J. M. H. Shaw, *Prosthechea mariae* (Ames) W. E. Higgins, *Stanhopea tigrina* Bateman, and *Vanilla planifolia* Andrews.

The 164 orchids were offered by 58 sellers, who published 344 offers during the period evaluated. Facebook Marketplace registered the highest number of sellers (30) and the lowest number of species (29). The highest numbers of offers and species were registered in Compra Compras (144 and 119, respectively). [Table 2](#) shows the 20 Mexican orchids with the largest number of offer publications. Among these species, eight are at risk according with NOM-059-SEMARNAT-2010, including *Chysis limminghei*, *Clowesia rosea*, *Cuitlauzina pendula*, *Encyclia adenocaula*, *Laelia autumnalis* (Lex.) Lindl., *Lycaste skinneri*, *Stanhopea tigrina*, and *Vanilla planifolia*. Six of them are also endemic to Mexico: *Clowesia rosea*, *Encyclia adenocaula*, *Laelia anceps* Lindl., *Laelia autumnalis*, *Stanhopea martiana*, and *S. tigrina*.

Places where orchids are offered in e-commerce. The publications of orchid offerings (344 offers) originated in 26 cities belonging to 12 Mexican states ([Table 3](#)). A single user posted an offer without specifying the state or city of origin. Almost 80 % of these publications originated in the state of Veracruz, mainly from the cities of Ixtaczoquitlan, Cordoba, Fortin, and Xalapa de Enriquez. Far behind were the states of Chihuahua (6.39 %), Morelos and Puebla (4.37 %). Over the half (54.38 %) of users posting orchid offers were from the state of Veracruz, followed by Puebla (10.52 %), Morelos (8.77 %) and Mexico City (5.26 %). In Chihuahua, the second state in orchid offers, all offers were made by a single user located in Ciudad Juarez. From the 164 orchids registered in this study, 70.73 % of them were offered in the state of Veracruz, followed by Morelos and Puebla (7.32 % each), Chihuahua (5.49 %) and Mexico City (2.43 %). The lowest e-commerce activity was recorded in the states of Chiapas (one post, one seller) and Oaxaca (two posts, two sellers), which are the Mexican states with the highest orchid richness.

Table 2. Most frequent orchids native to Mexico in the e-commerce. Conservation status according to NOM-059-SEMARNAT-2010: Pr = subject to special protection, A = threatened, P = endangered, NT = not threatened. * = priority species for the conservation in Mexico according to SEMARNAT (2014).

| Specie | Conservation status | Platforms | Posts | Sellers |
|--|---------------------|-----------|-------|---------|
| <i>Laelia anceps</i> Lindl. * | NT | 3 | 12 | 10 |
| <i>Oncidium sotoanum</i> R. Jiménez & Hágsater | NT | 3 | 5 | 4 |
| <i>Oncidium sphacelatum</i> Lindl. | NT | 2 | 5 | 4 |
| <i>Stanhopea martiana</i> Bateman ex Lindl. * | NT | 2 | 5 | 2 |
| <i>Vanilla planifolia</i> Andrews | Pr | 1 | 5 | 4 |
| <i>Cuitlauzina pendula</i> Lex. | A | 2 | 4 | 3 |

| Specie | Conservation status | Platforms | Posts | Sellers |
|--|---------------------|-----------|-------|---------|
| <i>Laelia autumnalis</i> (Lex.) Lindl. * | Pr | 3 | 4 | 3 |
| <i>Prosthechea cochleata</i> (L.) W.E. Higgins | NT | 3 | 4 | 4 |
| <i>Rhyncholaelia glauca</i> (Lindl.) Schltr. | NT | 3 | 4 | 4 |
| <i>Stanhopea saccata</i> Bateman | NT | 3 | 4 | 2 |
| <i>Stanhopea tigrina</i> Bateman * | A | 2 | 4 | 2 |
| <i>Brassavola nodosa</i> (L.) Lindl. | NT | 2 | 3 | 2 |
| <i>Chysis limminghei</i> Linden & Rchb. f. | A | 2 | 3 | 2 |
| <i>Clowesia rosea</i> Lindl. * | A | 3 | 3 | 2 |
| <i>Encyclia adenocaula</i> (Lex.) Schltr. * | A | 3 | 3 | 2 |
| <i>Encyclia cordigera</i> (Kunth) Dressler | NT | 2 | 3 | 1 |
| <i>Epidendrum radicans</i> Pav. ex Lindl. | NT | 2 | 3 | 3 |
| <i>Gongora galeata</i> (Lindl.) Rchb. f. | NT | 3 | 3 | 3 |
| <i>Lycaste deppei</i> (Lodd.) Lindl. | NT | 2 | 3 | 3 |
| <i>Lycaste skinneri</i> (Bateman ex Lindl.) Lindl. | P | 2 | 3 | 2 |

Table 3. Number and percentage of posts, users posting orchid offers and orchids offered by federative entity of México in the e-commerce.

| State | Posts | | Vendors | | Orchids | |
|-------------|--------|------------|---------|------------|---------|------------|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Veracruz | 274 | 79.65 | 31 | 54.38 | 116 | 70.73 |
| Chihuahua | 22 | 6.3 | 1 | 1.75 | 9 | 5.48 |
| Puebla | 15 | 4.3 | 6 | 10.52 | 12 | 7.32 |
| Morelos | 15 | 4.36 | 5 | 8.77 | 12 | 7.32 |
| Mexico City | 4 | 1.16 | 3 | 5.26 | 4 | 2.44 |
| Tlaxcala | 3 | 0.87 | 2 | 3.50 | 2 | 1.22 |

Orchids e-commerce

| State | Posts | | Vendors | | Orchids | |
|-----------------|------------|------------|-----------|------------|------------|------------|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Oaxaca | 2 | 0.58 | 2 | 3.50 | 1 | 0.61 |
| Guerrero | 2 | 0.58 | 1 | 1.75 | 1 | 0.61 |
| State of Mexico | 2 | 0.58 | 2 | 3.50 | 2 | 1.22 |
| Michoacan | 2 | 0.58 | 2 | 3.50 | 2 | 1.22 |
| Chiapas | 1 | 0.29 | 1 | 1.75 | 1 | 0.61 |
| Tamaulipas | 1 | 0.29 | 1 | 1.75 | 1 | 0.61 |
| Not specified | 1 | 0.29 | 1 | 1.75 | 1 | 0.61 |
| Total | 344 | 100 | 57 | 100 | 164 | 100 |

Verification of environmental regulations in orchid e-commerce. Information that allows verifying whether platforms and users comply with Mexican environmental regulations is shown in [Table 4](#). The terms and policies of use of Facebook (www.facebook.com/policies_center) state that sale postings must be in accordance with the applicable laws in the country and must not constitute, facilitate, or promote illicit activities. In addition, offering postings whose purpose is to buy, sell, exchange, donate, give away or solicit endangered species or parts thereof are restricted. The terms and conditions of use of Mercado Libre (www.mercadolibre.com.mx/ayuda/terminos-y-condiciones-uso-del-sitio_2090) do not allow posting advertisements of prohibited products included in its own list or that are not in compliance with the laws of the country, which covers endangered flora species or whose sale is against the law. This platform specifies that sellers must comply with regulatory obligations and they must have registrations, permits or authorizations required by the applicable regulations for the sale of the items offered, and those who violate this policy will be warned with the suspension of their user account. In Compra Compras, no information about terms, conditions or user policies were found and, therefore, it was not possible to verify if offer postings of orchid complies with the country regulations.

The users of the three platforms do not provide evidence indicating that their offer postings for orchids, especially those native to Mexico, constitute a legal activity that complies with the local environmental regulations. The postings do not indicate if specimens were propagated for sale, or whether they constitute items for commercial management authorized by SEMARNAT, or whether users have orchid collections registered by this authority, or whether they can demonstrate the legal provenance of specimens. This lack of compliance suggests that users perform an activity that would fall into illicit wildlife trafficking.

Comparison between e-commerce and traditional markets. Among the orchid species offered in e-commerce, 43 were also recorded for sale in traditional markets. For the same species, the price was higher in e-commerce platforms than in traditional markets. [Table S2 \(Supplementary material\)](#) shows differences in prices for common orchids in both markets. In e-commerce, the price ranges from \$100 MX, as the case of *Gongora galeata* (Lindl.) Rchb. f. and *Laelia anceps* Lindl., to \$2,500 MX, as the case of *Laelia dawsonii*. The updated prices of an orchid specimen in traditional markets range from \$12 MX for *Epidendrum radicans* Pav. ex Lindl. to \$250 MX for *Encyclia rze-*

Table 4. Verification of compliance with environmental regulations at three online platforms of e-commerce (Compra Compras, Facebook Marketplace, Mercado Libre) and users in orchid e-commerce in Mexico from October to December 2020.

| Legal instrument | Legal description | Facebook Marketplace | Mercado Libre | Compra Compras |
|--|---|---|---|--|
| Mexican Federal Criminal Code (CPFM). Title XXX Chapter II on Biodiversity | Art. 420. frac. IV. It imposes prison sentences and penalties to anyone who unlawfully carries out any activity for trafficking purposes, or captures, possesses, transports, collects, introduces into the country or extracts from it, any specimen, its products or by-products and other genetic resources, of a species of wild flora, considered endemic, threatened, endangered, subject to special protection, or regulated by any international treaty to which Mexico is a party. | <i>Platform.</i> The use conditions and Policies consider the commercial use that includes advertisements and sale of products on the platform, where the user is aware that it is used in accordance with applicable laws, rules, and regulations. Prohibited Content indicates that advertisements on the platform must not constitute, facilitate, or promote illegal products, services, or activities. <i>Users.</i> There are posts offering specimens of wild and at-risk orchids without evidence that the activity is performed in a lawful manner. | <i>Platform.</i> The List of Products and Services does not allow to publish or sell items prohibited by the General Terms and Conditions of the platform or the applicable laws. <i>Users.</i> There are posts offering specimens of wild and at-risk orchids without evidence that the activity is performed in a lawful manner. | <i>Platform.</i> It does not display information about products whose sale is prohibited or contrary to the laws of the country. <i>Users.</i> There are posts offering specimens of wild and at-risk orchids without evidence that the activity is performed in a lawful manner. |
| General Wildlife Law (LGVS) Title V Chapter X Legal provenance | Art. 50. When providing registries and authorizations related to specimens, parts, and derivatives of wild species out of their natural habitat, the authorities must verify their legal provenance. Art. 51. The legal provenance must be demonstrated, in conformity with the provisions of the Regulation, with the corresponding remittance note or invoice. | <i>Platform.</i> The Community Standards, among the restricted goods and services, include not making posts whose purpose is to buy, sell, exchange, donate, give away or solicit endangered species or parts thereof. <i>Users.</i> There are posts offering specimens of wild and at-risk orchids without evidence that the legal provenance of the specimens. Although the customer may have a remittance note (purchase voucher), in its origin the offered specimen did not have a corresponding document. | <i>Platform.</i> The list of Products and Services whose offer, request, publication, purchase or sale are prohibited includes endangered flora or whose sale is contrary to the law. <i>Users.</i> There are posts with offers for wild and at-risk orchids without evidence of the legal provenance of the specimens. Although the customer may have a remittance note (purchase voucher), in its origin the offered specimen did not have a corresponding document. | <i>Platform.</i> There is no information about the prohibition of sale or supply of wild flora species in the country. <i>Users.</i> There are posts with offers for wild and at-risk orchids without evidence of the legal provenance of the specimens. Although the customer may have a remittance note (purchase voucher), in its origin the offered specimen did not have a corresponding document. |

| Legal instrument | Legal description | Facebook Marketplace | Mercado Libre | Compra Compras |
|--|---|---|---|---|
| Title VI Chapter IX Conservation of wildlife out its natural habitat | Art. 78. Public or private collections of specimens of wild species must register and update their data with the corresponding authority, in the registry kept for that purpose, in accordance with the provisions of the regulation. | <i>Users.</i> Some users post offers for wild orchids, which shows that they have a private collection, but do not provide information that it has been registered with the corresponding authority (SEMARNAT). | <i>Users.</i> Some users post offers for wild orchids, which shows that they have a private collection, but do not provide information that it has been registered with the corresponding authority (SEMARNAT). | <i>Users.</i> Some users post offers for wild orchids, which shows that they have a private collection, but do not provide information that it has been registered with the corresponding authority (SEMARNAT). |
| Title VII Chapter I Extractive management | Art. 83. The extractive management of specimens, parts and derivatives of wildlife requires a previous authorization from the Ministry (SEMARNAT). These uses may be authorized for economic purposes. | <i>Users.</i> In some cases, the photos in the posts show wild specimens that have been extracted from their habitat, but do not include information regarding the authorization for its commercial management emitted by SEMARNAT. | <i>Users.</i> In some cases, the photos in the posts show wild specimens that have been extracted from their habitat, but do not include information regarding the authorization for its commercial management emitted by SEMARNAT. | <i>Users.</i> In some cases, the photos in the posts show wild specimens that have been extracted from their habitat, but do not include information regarding the authorization for its commercial management emitted by SEMARNAT. |
| Chapter V Non extractive management | Art. 99. The non-extractive management of wildlife requires a previous authorization of SEMARNAT, which must be granted in accordance with the provisions established in this chapter, to guarantee the wellbeing of the specimens of wild species, the continuity of their populations and the conservation of their habitats. | <i>Users.</i> Some users may propagate wild species for commercial management, these being the ones that appear in their posts, but do not present information regarding the corresponding authorization emitted by SEMARNAT. | <i>Users.</i> Some users may propagate wild species for commercial management, these being the ones that appear in their posts, but do not present information regarding the corresponding authorization emitted by SEMARNAT. | <i>Users.</i> Some users may propagate wild species for commercial management, these being the ones that appear in their posts, but do not present information regarding the corresponding authorization emitted by SEMARNAT. |

| Legal instrument | Legal description | Facebook Marketplace | Mercado Libre | Compra Compras |
|--|---|--|---|--|
| General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) Title II Biodiversity Chapter III Wild flora and fauna | <p>Art. 79. For the preservation and sustainable use of wild flora, the combat against trafficking or illicit appropriation of species will be considered as a criterion.</p> <p>Art. 80. The criteria for the preservation and sustainable use of wild flora must be considered in the approval of concessions, permits and, in general, of all kinds of authorizations for the management, possession, administration, conservation, repopulation, propagation, and development of wild flora.</p> <p>Art. 87. The use of wild flora species in economic activities, may be authorized when particulars guarantee their controlled reproduction or development in captivity or semi-captivity, or when the exploitation rate is lower than the natural renewal rate of the populations, in accordance with the official standards issued by the Ministry (SEMARNAT).</p> <p>Art. 84. The management of non-timber resources will only require a written notification given by the competent authority (SEMARNAT).</p> <p>Art. 85. Authorization is required for management of whole orchid plants from forest vegetation.</p> | <p><i>Platform.</i> Under the Community Norms, restricted goods and services include publications whose purpose is to buy, sell, exchange, donate, give away or solicit endangered species or parts thereof. This supports the combat against trafficking or illicit appropriation of species. However, evidence of concessions, permits or authorizations issued by SEMARNAT for the commercial management of wild orchids is not requested.</p> <p><i>Users.</i> There is no evidence of concessions, permits or authorizations issued by SEMARNAT for commercial management of wild orchid specimens from Mexico.</p> | <p><i>Platform.</i> The list of products and services whose offering, solicitation, publication, purchase, or sale is prohibited includes endangered flora or whose sale would be contrary to law.</p> <p><i>Users.</i> There is no evidence of concessions, permits or authorizations issued by SEMARNAT for commercial management of wild orchid specimens from Mexico.</p> | <p><i>Platform.</i> There is no information about the prohibition of sale or supply of wild flora species in the country.</p> <p><i>Users.</i> There is no evidence of concessions, permits or authorizations issued by SEMARNAT for commercial management of wild orchid specimens from Mexico.</p> |
| General Law of Sustainable Forestry Development (LGDFS) Section IV On the management of non-timber forest resources | <p>Art. 84. The management of non-timber resources will only require a written notification given by the competent authority (SEMARNAT).</p> <p>Art. 85. Authorization is required for management of whole orchid plants from forest vegetation.</p> | <p><i>Platform.</i> Prohibited Content states that postings on the platform must not constitute, facilitate, or promote illicit products, services, or activities.</p> | <p><i>Platform.</i> The list of Products and Services establishes that users must comply all pertinent regulatory obligations and have the registrations, authorizations, permits and/or authorizations required by applicable regulations for the sale of the goods and services offered.</p> | <p><i>Platform.</i> There is no information about the prohibition of sale or supply of wild flora species in the country.</p> |

| Legal instrument | Legal description | Facebook Marketplace | Mercado Libre | Compra Compras |
|--|---|--|--|---|
| NOM-059-SEMARNAT-2010 Normative annex III | Enlists the species of wild orchids considered in some category of risk, protected by Mexican law, for which their management requires authorization from SEMARNAT. | <i>Users.</i> The publications do not present the authorization issued by SEMARNAT for the commercial management of orchid specimens when they have been extracted from their habitat. <i>Platform.</i> There are posts offering species included in this regulation, but there is no information on whether they have the corresponding authorization from SEMARNAT. | <i>Users.</i> The publications do not present the authorization issued by SEMARNAT for the commercial management of orchid specimens when they have been extracted from their habitat. <i>Platform.</i> There are posts offering species included in this regulation, but there is no information on whether they have the corresponding authorization from SEMARNAT. | <i>Users.</i> The publications do not present the authorization issued by SEMARNAT for the commercial management of orchid specimens when they have been extracted from their habitat. <i>Platform.</i> There are posts offering species included in this regulation, but there is no information on whether they have the corresponding authorization from SEMARNAT. <i>Users.</i> None of the users posting offers for orchids included in this regulation presented the corresponding authorization from SEMARNAT. |
| | | <i>Users.</i> None of the users posting offers for orchids included in this regulation presented the corresponding authorization from SEMARNAT. | <i>Users.</i> None of the users posting offers for orchids included in this regulation presented the corresponding authorization from SEMARNAT. | <i>Users.</i> None of the users posting offers for orchids included in this regulation presented the corresponding authorization from SEMARNAT. |

dowskiana Soto Arenas. Prices for ten species posted in e-commerce platforms were higher than \$500 MX, including *Coelia bella* (Lem.) Rchb. f., *Cuitlauzina pendula*, *Laelia anceps*, *Laelia dawsonii*, *Lycaste skinneri*, *Mormodes maculata* (Klotzsch) L.O. Williams, *Mormodes nagelii* L.O. Williams, *Prosthechea karwinskii*, *Stanhopea saccata* G. Gerlach & Dodson, and *Stanhopea tigrina*. In traditional markets, prices of these species range from \$15.16 MX (*P. karwinskii*) to \$ 192.19 MX (*S. tigrina*).

The profile of orchid sellers in e-commerce was assumed according to IFT (2019). The percentage of the Mexican population using social networks increases up to 99 % in young people (18-34 years old), with at least bachelor's degree of scholarship, living in urban areas, with monthly incomes between \$12,883 and \$27,307 MX. We assume that most these features are present in users posting orchid offers in e-commerce, as well as orchid hobbyists interested in acquiring specimens through social networks.

Discussion

How many orchids are present in this trade? The number of orchids offered in e-commerce documented here was higher than that recorded in traditional markets (Cruz-García *et al.* 2015, Emeterio-Lara *et al.* 2016, Jiménez-López *et al.* 2019a, b, Martínez-Gómez 2014). However, in Xalapa (state of Veracruz), there was a similar number of orchids traded in both market types, with 167 species (Flores-Palacios & Valencia-Díaz 2007). The combined number of orchids traded in the six traditional markets (205) was higher than that recorded for e-commerce (164). Indeed, while in traditional markets all species are native to Mexico, the half of the orchids offered in the e-commerce are nonnative or hybrids. The twenty species more frequently offered in e-commerce are Mexican orchids with ornamental value and almost half of them are endemic to this country or are protected. The traits of orchids offered in e-commerce that customer prefer are: (i) they must be native to Mexico (origin), (ii) they must preferentially be endemic to this country or at risk (rarity condition), and (iii) they must have showy flowers (horticultural potential). Additionally, orchid sellers in e-commerce may obtain additional profits offering nonnative orchids or valuable hybrids.

Where do orchid offers originate for e-commerce in Mexico? The places where posts for orchid sale originated do not always coincide with areas of high diversity for this group in Mexico. Veracruz was the Mexican state that concentrated most orchid e-commerce, with almost 80 % of the publications, more than 50 % of the users and about 70 % of species or hybrids. Veracruz is the third state in terms of orchid richness in Mexico, with almost 430 species (Viccón-Esquivel *et al.* 2021). However, the states of Chiapas and Oaxaca, which concentrate the highest orchid richness with about 700 species each (Solano-Gómez *et al.* 2016, Beutelspacher-Baigts & Moreno-Molina 2018), made a very low contribution to the e-commerce of specimens. In contrast, the state of Chihuahua, which has 56 orchids species only (Solano-Gómez *et al.* 2019), was the second federative entity in terms of publications and the third one in terms of the number of orchids offered, all of them by a single user. Veracruz is a state with great orchidological tradition in Mexico, especially at its central and mountainous region, which have been visited by naturalists and artists since the beginning of the XIX century to document its orchid richness and promoted the interest for these plants (Aguirre-León 2021). Numerous hobbyists in this region interact with social networks specialized in orchids and, as seen here, many of them make sales posts.

Trading of orchids in Mexican traditional markets shows a different picture. These markets are close to forests where orchids are extracted, where they constitute important components of the native vegetation and some species are highly appreciated by local people. Available studies indicate that these orchid sellers inhabit the ecosystems close to villages where markets are located, and these sellers harvest the specimens (Martínez-Gómez 2014, Cruz-García *et al.* 2015, Molina-Luna *et al.* 2015, Emeterio-Lara *et al.* 2016, Jiménez-López *et al.* 2019a, b). Market, harvest areas, sellers and buyers are components of orchid trade in traditional markets and they coexist with orchids and forests at a local geographical scale.

Does e-commerce comply with Mexico's environmental regulations? User policies of Facebook and Mercado Libre clearly indicate that posts for wild flora are forbidden when Mexican laws (LGVS, LGEEPA) are not complied. However, both platforms have posts for Mexican native orchids, including species at risk. These postings show that these platforms lack of mechanisms to verify compliance environmental policies when wild flora is traded. Because the user policies of Compra Compras were not available, we are unable to know what items are prohibited or restricted. This platform has operated since 2017 in 33 countries, among which eight are located in Latin America, including Mexico. This implies the possibility of international trade for wild species outside CITES regulation.

In the e-commerce of Mexican native orchids, no user provided information about whether specimens were propagated for sale, if they have authorization of SEMARNAT for commercial management (LGVS Art. 83) or documentation to prove its legal provenance (LGVS Art. 50 and 51). Indeed, the pictures accompanying some posts show specimens that are not rooted on substrate, with damage and blemishes due to herbivory or infections. These traits indicate that specimens were extracted from forests instead of constituting healthy plants propagated and maintained on cultivation. Mexican regulations establish that extractive or nonextractive management of wild flora species requires authorization from SEMARNAT (LGVS Art. 83 and 99, LGEEPA Art. 80 and 87, LGDFS Art. 84 and 85). On the other hand, some users maintain orchids on cultivation and propagate specimens for sale. However, public or private collections where Mexican wildlife is managed outside natural habitats must be registered in SEMARNAT (LGVS Art. 78). In e-commerce, it seems that users extract Mexican wild orchids, keep their collections and post them for sale. Nevertheless, no user provided evidence demonstrating that the harvesting was performed with authorization for extractive management.

The uprising of social networks for wildlife trade currently represents a challenge to achieve the objectives of Mexican environmental regulations, including the protection and sustainable use of wildlife and fighting the illicit trafficking. Native orchids traded on social networks shift the platforms into scenarios for illicit wildlife trafficking, and they can generate environmental crimes and that represent additional risks for its conservation (Bennett 2011, Carpio-Domínguez *et al.* 2018). The problem is exacerbated because interactions between sellers and buyers multiply in a short time while they remain anonymous (Brenner 2002, Grabosky 2013, Lavorgna 2014, Khabbach *et al.* 2022).

Profits and seller profile between e-commerce and traditional markets. An orchid seller can obtain higher profits in e-commerce than in traditional markets. Seller in traditional markets are generally adult women from rural areas with poor scholarship that usually speaks an indigenous language, and their main activities is related to field work (Martínez-Gómez 2014, Cruz-García *et al.* 2015, Jiménez-López *et al.* 2019a). This type of sellers performs the activity once a week, during the orchid flowering season, with possible profits around \$130 to \$1,084 MX in the state of Chiapas (Jiménez-López *et al.* 2019b) and \$296 to \$2,050 MX in the state of Oaxaca (Cruz-García *et al.* 2015). In these states, buyers acquire flowering specimens for temporary adornments rather than for cultivating them. In e-commerce, sellers can obtain profits equal or higher than those abovementioned just when selling of a single specimen. Indeed, a posting may remain for weeks or months because buyers search for specific attributes in orchids (native, rarity, showy flowers), regardless of whether specimens have flowers or not, which are integrated into a collection. Orchid trade in traditional markets basically involves two actors, the sellers and the buyers, where sellers harvest orchids in forest and intermediaries are usually absent. E-commerce involves an additional actor, the platforms, that may constitute intermediaries between nurseries, growers and harvesters that provide specimens to customers while they do not participate in the platform.

According to IFT (2019), social network users are concentrated in the young Mexican population from urban areas, with bachelor degree as minimum scholarship. The profile of an orchid seller in e-commerce may include these characteristics, having an electronic device with access to social networking applications, investing resources in maintaining orchids under cultivation, having means to make online banking transactions, and sending specimens to any part of the country. In this study, all orchid offer posts originated in urban areas with access to the internet. The most important difference between e-commerce and traditional markets was in the price of specimens of the same

species. Possible explanations may be that e-commerce sellers use the monopoly power of the platform to set higher prices, transportation costs are higher and, although customers can virtually visit the seller with minimal transportation costs, the cost of shipping specimens is not evenly distributed among consumers. Additionally, the value of a species in e-commerce is determined by a complex social process that depends on the beliefs of sellers and buyers about the future prices, rather than on market supply and demand. According to some authors (Rochet & Tirole 2003, Jeitschko *et al.* 2018, van Heck 2021), the price difference between the two markets reflects speculative behavior.

Code of conduct for orchid trade in social networks. Among the United Nations member countries, Mexico ranks fourth in terms of the highest rate of organized crime considering the illegal markets operating in the country, the structure and influence of criminal actors, and the capacity of government to disrupt criminal activities through public policies (Global Initiative 2022). Attention to cybercrimes under the control of organized crime has been a priority for Mexican authorities over wildlife trafficking through social networks. However, the collaborative effort that may arise between NGOs, the Federal Attorney Office for Environmental Protection (PROFEPA), Mexico Preventive Cybernetic Police (PCP), hobbyists and academics will help to monitor orchid trade through social networks to verify compliance with environmental regulations. To regulate and monitor wild orchid e-commerce, a set of actions based on previous studies (Hinsley *et al.* 2016a, b, Wong & Liu 2019) are proposed here: (1) user policies, terms and conditions of online platforms must include a link to the list of Mexican wild plants at risk, the normative annex III of NOM-059-SEMARNAT-2010; (2) the platform users must have authorization to commercial exploitation when posting offers for sale, exchange or shipment of Mexican orchids, as well as the documentation that accredits their legal provenance; (3) when the previous points are not observed, the platform should block sale transactions for preventing illicit traffic and environmental crimes; (4) platforms must identify the location of foreigner consumers to block transactions outside CITES regulations that could constitute illegal international wildlife traffic; and (5) for illicit actions, the content of the post offer must constitute evidence for criminal intent. The PCP can obligate to platform owners to identify the offending person (SSP 2017) and submit the charges for legal processes (Carpio-Domínguez *et al.* 2018).

Supplementary material

Supplemental data for this article can be accessed here: <https://doi.org/10.17129/botsci.3159>

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Ethics Statement

All authors read and approved the final manuscript and declare that there is no conflict of interest. The confidentiality each user of the social networks revised was guaranteed.

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