

Prioritizing the Conservation of Epiphytic Bromeliads Using Ethnobotanical Information from a Traditional Mexican Market

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The study of traditional markets is a useful tool in the development of studies on species management and conservation because it allows us to identify the species under collection pressure as well as the intensity of their collection. The “Mercado de Jamaica” in Mexico City, Mexico, is one of the main places where cut flowers and foliage are sold. Given that wild bromeliads commercialized in Mexico originate from natural populations, their collection has put certain species at risk, and developing management and conservation programs for them has become an urgent priority. Hence, we carried out an ethnobotanical study focused exclusively on bromeliads used as cut flowers and/or foliage. To obtain information on the species, plant parts, number of plants sold, and vendor characteristics, we made monthly visits to the Mercado de Jamaica over a year (January 2014 to January 2015) to conduct semistructured interviews with bromeliad vendors. We also bought species samples for taxonomic identification. Twelve species belonging to the genus *Tillandsia* L. were identified, 66% of which are endemic to Mexico. Approximately 60,300 inflorescences and/or whole plants are sold per year. *Tillandsia punctulata* Schltdl. & Cham. was sold the most (16,200 plants), followed by *Tillandsia makoyana* Baker (9,200 inflorescences). Sale prices varied between MXN 10–70 (Mexican pesos). Bromeliads were collected from the states of Veracruz, Puebla, and Michoacán. Of the 10 bromeliad vendors, 60% were collectors between 26 and 65 years old. The collection of wild bromeliads for sale as cut flowers or foliage could have a strong impact on the conservation of these species because of the loss of adult individuals—adulthood being the most vulnerable stage in the life cycles of these plants. This loss, along with the loss of inflorescences, which eliminates the seeds that give rise to new individuals and constantly colonize new trees, could threaten the survival of epiphytic bromeliad populations.

El estudio de la venta de especies silvestres en los mercados, es una herramienta muy útil en el desarrollo de estudios de manejo y conservación de especies, ya que nos permiten identificar cuáles especies están sufriendo presiones de recolección, así como la intensidad de las mismas. El mercado de Jamaica de la Ciudad de México es uno de los principales centros de oferta y comercialización de flores de corte y follajes del país. En 2010 se reportó la venta de 60 especies de plantas silvestres en dicho mercado, de las cuales 12 pertenecían a la familia Bromeliaceae. Dado que la mayoría de las bromelias silvestres comercializadas en México provienen del saqueo de poblaciones naturales y que esto, ha puesto en riesgo a ciertas especies, se hace prioritario desarrollar planes para su manejo y conservación. Por ello, se planteó desarrollar un estudio etnobotánico exclusivamente de las bromelias utilizadas como follaje y/o flor de corte. Para obtener información acerca de las especies, partes y cantidades comercializados, así como características de los

¹Received 23 March 2015; accepted 19 January 2016; published online 2 March 2016

vendedores, se realizaron visitas mensuales al mercado de Jamaica (enero 2014–enero de 2015), donde se llevaron a cabo entrevistas semi estructuradas a los vendedores de bromelias; se compraron ejemplares de las especies encontradas para su identificación taxonómica. Se identificaron 12 especies pertenecientes al género *Tillandsia*, de las cuales el 66 % son endémicas al país. Aproximadamente 60,300 inflorescencias y/o plantas, se comercializan al año, siendo *Tillandsia punctulata* la más comercializada (16,200 plantas), seguida por *Tillandsia makoyana* (9,200 inflorescencias). Los precios de venta oscilan entre los 10–70 pesos/ inflorescencia. Las bromelias proceden de los estados de Veracruz, Puebla y Michoacán y son vendidas vendedores varones de entre 26 y 65 años. El impacto de recolección de bromelias silvestres para la venta como follaje y flor puede llegar a tener un fuerte impacto en la conservación de las especies comercializadas, debido a la pérdida de individuos adultos (el estado más vulnerable del ciclo de vida de estas especies), así como a la pérdida de las inflorescencias que produzcan semillas, las cuales son primordiales tanto para la incorporación de nuevos individuos, como para la constante colonización de nuevos forofitos, hecho fundamental para la supervivencia de las poblaciones de bromelias epífitas.

Key Words: Bromeliaceae, Mexico, vascular epiphytes, ethnobotany.

Introduction

Traditional markets are an important source of ethnobotanical knowledge. Such knowledge can be useful for developing plans for managing and conserving species because the species under pressure from gathering, the sites where they are gathered, and the parts used can be determined (Albuquerque et al. 2007; Almeida and Albuquerque 2002; Ghorbani et al. 2014). In addition, sociocultural information about the people involved in this activity makes it possible to focus on those species toward which conservation strategies should be directed and, thus, increases the possibility that such strategies will be successful (Caro 2004; Lawrence et al. 2005).

The Mercado de Jamaica is one of the most important centers for the sale and distribution of cut flowers and foliage in Mexico. It was officially established in 1957, but records show activities dating from 1885 (Díaz 2015). About 5,000 types of flowers and ornamental plants are offered for sale there, of which 131 are wild plants (Munguía-Lino et al. 2010). A recent study on marketing wild plants for ornamental purposes in the Tenancingo and Jamaica markets (Munguía-Lino et al. 2010) reported the sale of 13 species of bromeliads, and mentioned that inflorescences are sold for two of those species—*Tillandsia prodigiosa* (Lem.) Baker and *T. viridiflora* (Beer) Baker.

In Mexico, the use of epiphytic bromeliads as ornamentals is well documented. Munguía-Lino et al. (2010) mentioned these epiphytes being used as potted plants, especially during the religious periods of Holy Week and Christmas. This was supported by Haeckel (2008), who reported the use of

inflorescences of three species of epiphytic bromeliads to create “Floral Arches” that are used to adorn church doors in Coatepec, Veracruz. Mondragón (2008) found that 21 species of epiphytic bromeliads were sold in markets in the city of Oaxaca in December to adorn crèches. In the city of Zaachila in Oaxaca, Méndez-García and Mondragón (2012) reported the use of 17 species to adorn chapels during Holy Week. However, the use of epiphytic bromeliads as cut flowers or foliage has been only superficially documented (Munguía-Lino et al. 2010).

It is well known that most epiphytic bromeliads being sold in traditional markets for use during religious activities are taken from wild populations (Flores-Palacios and Valencia-Díaz 2007; Haeckel 2008; Mondragón and Villa-Guzmán 2008). This form of collection has endangered the permanence of some natural bromeliad populations (Mondragón and Ticktin 2011) and, therefore, it is necessary to develop plans for their management and conservation. Some of the first facts that must be learned in order to develop such plans are related to how the plants are used; that is, information is needed about which species are being used and are, therefore, under pressure from gathering, which part or parts of the plant are used, gathering intensity, provenance of the plants, and the social characteristics of the people involved in the gathering (gender, age, social status, and education). Ethnobotanical studies allow us to answer such questions.

Much of this information is unavailable for those epiphytic bromeliads marketed as cut flowers and/or foliage. Thus, to provide the basis for developing management and

conservation plans, we conducted an ethnobotanical study in the Mercado de Jamaica.

Methods

STUDY SITE

The Mercado de Jamaica is located on the corner of Congreso de la Unión Avenue and Morelos Avenue in the Venustiano Carranza Precinct, México City. It has 1,150 stalls devoted to cut flowers, flower arrangements, flower pots, and wild plants.

DATA COLLECTION

In January 2014 we visited 1,150 stalls, 7 of which sold epiphytic bromeliad inflorescences and/or leaves. For each of the seven stalls we conducted a monthly semistructured interview with the vendors (Alexiades 1996) to determine the species sold, sales volumes, fluctuations in volumes and prices throughout the year. Prior to conducting the interviews we explained the objectives of our research to the vendors and asked them for their permission to be interviewed.

At each stall we noted the species being sold, estimated their volumes, and recorded prices. The annual rate of sale per species was estimated by adding the monthly number of inflorescences or individuals noted for each species during the interviews (January 2014 to January 2015). The total number of inflorescences and individuals of epiphytic bromeliads sold yearly at the Mercado de Jamaica was estimated by adding the quantities of all the species recorded in the study.

A specimen of each species was purchased to create a sample herbarium that could help with taxonomic identification. The specimens were deposited in the Herbarium of the Centro de Investigación Científica de Yucatán (CICY).

Results

Of the 12 species of bromeliads identified (Table 1), 11 were sold as inflorescences; one species, commonly known as “cebollín” (*Tillandsia* sp.), was sold as foliage. We were unable to identify “cebollín” to species level because our samples lacked the necessary reproductive structures.

In general, individuals are sold with inflorescences from which the leaves are removed, leaving

only the inflorescence. This was not the case for *Tillandsia punctulata*, *T. imperialis* E. Morren ex Roezl, and *T. deppeana* Steud., for which the vendors left some leaves attached to the inflorescence base because they thought the leaves made the inflorescences prettier. Inflorescences were sold by the unit, except those from *T. punctulata*, which were sold in bunches of five individuals each. “Cebollín” was sold in bunches of ten individuals.

From January 2014 to January 2015, 118,300 epiphytic bromeliad individuals or inflorescences were on sale at the Mercado de Jamaica. According to the vendors, the volume of epiphytic bromeliads sold equaled the volume offered for sale, because the long lives of the foliage and inflorescences meant that they could remain on sale for a long time, allowing all individuals shown to be sold. Sales volume varied for species and by time, as can be seen in Table 1 and Fig. 1. The volumes on sale depended on what the gatherers found flowering in the field so, for example, *T. prodigiosa* (Lem.) Baker was sold only in October, as was *T. tricolor*. On the other hand, *T. punctulata* was sold all year long, but its sales were highest in December, January, and February. “Cebollín,” which does not depend on having flowers in order to be sold, was sold throughout the year, although in some months it was sold in larger volumes.

The species of bromeliads offered for sale come principally from the states of Puebla, Michoacán, and Veracruz. They are sold in seven stalls in the Mercado de Jamaica, in addition to exotic foliage and other types of flowers. Ten people run the seven stalls found, 60% of whom are also gatherers. There are differences in the age ranges and educational levels of the gatherers/vendors and those who only sell. The age of the gatherers/vendors varied from 26 to 65 years, most of them had not finished elementary school, whereas the sellers varied from 18 to 32 years and their educational levels ranged from middle school to completing high school. In both cases, all those interviewed were men. The gatherers from Michoacán began selling bromeliads 30 years ago. They started by taking them to sell in the market because they thought the plants were pretty. However, those who brought and sold bromeliads from Puebla and Veracruz began 10 or 15 years ago. They commented that they began to sell bromeliads because they saw that they sold well.

Prices varied depending on the species, and on supply and demand, because when other vendors brought identical species, prices de-

TABLE 1. EPIPHYTIC BROMELIADS (*TILLANDSIA*) ON SALE IN THE MERCADO DE JAMAICA, MEXICO CITY, FROM JANUARY 2014 TO JANUARY 2015.

Species	Annual number of bromeliads on sale	Mean annual profit in Mexican pesos	Gathering sites	Type of vegetation	Endemic to Mexico	Risk category according to NOM-059
<i>T. prodigiosa</i> (Lem.) Baker	60	4,200	Mich	OF	Endemic	--
<i>T. tricolor</i> Schltdl. and Cham.	80	1,600	Ver, Pue	DPE, HLMF	Not endemic	T
<i>T. leiboldiana</i> Schltdl.	200	2,000	Ver, Pue	HLMF	Not endemic	--
<i>T. imperialis</i> E. Morren ex Mez	1,280	15,543	Ver	CF, POF	Endemic	T
<i>T. limbata</i> Schltdl.	2,800	47,600	Mich	CF, DPF, HLMF	Endemic	--
<i>T. langassana</i> Mez	4,280	62,255	Mich	POF	Endemic	--
<i>T. gymnotrypa</i> Baker	5,000	91,667	Mich, Ver	CF	Endemic	--
<i>T. deppiana</i> Steud.	7,200	128,571	Mich, Ver	CF	Endemic	--
<i>T. bourgaei</i> Baker	8,000	153,333	Mich, Ver	POF	Endemic	--
<i>T. makoyana</i> Baker	9,200	132,889	Mich, Ver	POF, OF, XS	Endemic	--
<i>T. punctulata</i> Schltdl. and Cham.	16,200	184,091	Ver, Pue	CF	Not endemic	--
" <i>Cebollin</i> "	64,000	72,320	Ver		???	--

Sites: Michoacan (Mich), Veracruz (Ver), Puebla (Pue); Type of vegetation: Oak Forest (OF), Dry Premontane Forest (DPE), Humid Lower Montane Forest (HLMF), Cloud Forest (CF), Pine-Oak Forest (POF), Xeric Scrub (XS). Risk category: Threatened (T) (Espejo-Serna et al. 2004; Hietz and Hietz-Seifert 1994; SEMARNAT 2010).

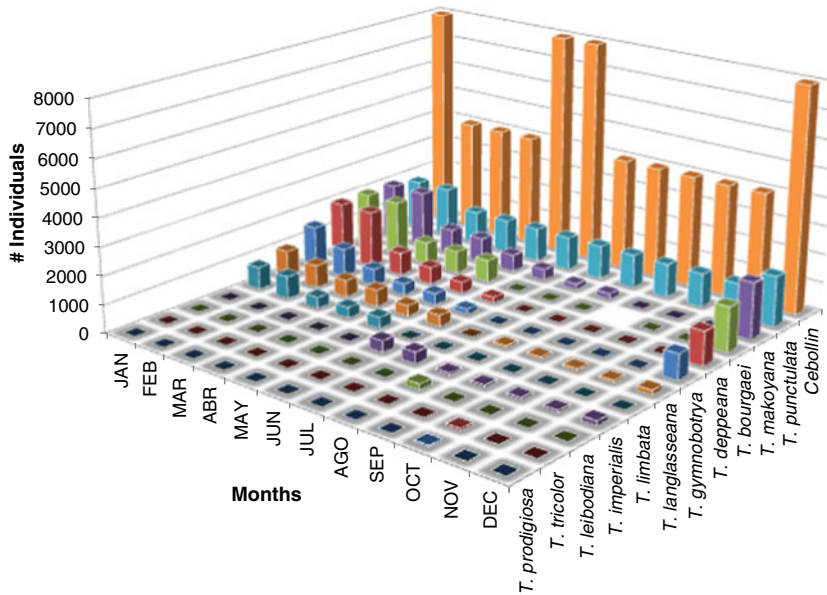


Fig. 1. Numbers of epiphytic bromeliads sold in the Mercado de Jamaica, Mexico City, from January 2014 to January 2015.

clined. Vendors raised prices for species that were in limited quantities, and for individuals of unusual colors or sizes.

Discussion

In recent years the sale of epiphytic bromeliads, particularly tillandsias, has increased considerably mainly because of their ornamental beauty, durability and easy maintenance (Anacleto et al. 2014; Negrelle et al. 2012). Unfortunately, many of the bromeliads offered for sale come from the wild, and this has endangered the permanence of their source populations (Flores-Palacios and Valencia-Díaz 2007; Negrelle et al. 2012; Read 1989). In Mexico, numerous species are gathered from natural populations. For example, Flores-Palacios and Valencia-Díaz (2007) report the sale of 20 species of epiphytic bromeliads in the markets of Jalapa, Veracruz, and Mondragón (2008) found 21 species on sale in markets in the central valleys of Oaxaca. These data, compared to those obtained in our study, suggest a low species richness of bromeliads in the Mercado de Jamaica (12 spp.). The differences, however, are probably related to the sources of gathered plants: vendors in the Mercado de Jamaica collected plants from their communities around Mexico City, whereas vendors in Veracruz and Oaxaca, although

also collecting from their own communities, were located in the states with the highest species richness of bromeliads in the country (Oaxaca 135 spp. and Veracruz 91 spp. [Espejo-Serna et al. 2004]).

Using market data and models of potential distribution of species in West Africa, van Andel et al. (2015) recommended that medicinal plant species with the most restricted distribution ranges and the highest harvesting rates should be given priority for conservation and sustainable harvesting. Based on that study, and our data on species and sale volumes in the Mercado de Jamaica, we would say that 66% of the species sold there should be prioritized in management and conservation plans, because as endemics their distribution ranges are limited (Table 1). We also propose that additional factors be considered as prioritization parameters. Apart from endemism, the vegetation type and particularly the vulnerability of species habitat (Table 1) should be considered. In our case, the endemic species, *T. gymnobotrya* Baker and *T. deppeana*, are gathered intensively (5,000 ind/year and 7,200 ind/year, respectively), yet they inhabit only cloud forests, which are considered to be the most endangered ecosystems in Mexico owing to changes in climate and in land use, and the small area they cover (CONABIO 2010). In this regard, although *T. punctulata* is not endemic to Mexico, it

is found only in cloud forest. Moreover, its year-round inflorescences have given rise to the intensive collecting and selling activities that have endangered the species.

From the standpoint of life history, all the epiphytic bromeliads should be prioritized in developing management and conservation plans because of their low growth rates. Their slow growth is related to the oligotrophic conditions of the epiphytic environment, and the fact that many of these epiphytes use the crassulacean acid metabolism pathway of photosynthesis, which means that they take up to 15 years before flowering (Mondragón et al. 2015).

In addition, studies of the population dynamics of epiphytic bromeliads have shown that rates of population growth (λ) depend on the survival of adult individuals (Mondragón and Ticktin 2011; Toledo-Aceves et al. 2014). So, for those species for which adult individuals are collected, there will be a direct negative impact on population size. Except for “cebollín,” we found all individuals sold to be adult bromeliads, which could be a big threat to the permanence of populations of these species. If we also consider that most populations of these epiphytic bromeliads have λ values close to or less than one ($\lambda = 1$, populations are stable; $\lambda < 1$, populations are decreasing; $\lambda > 1$, populations are growing [Caswell 2001]), the harvesting of individuals, especially adults, is unsustainable (Mondragón and Ticktin 2011; Toledo-Aceves et al. 2014). In the case of *T. punctulata*, we found that over 16,200 adult individuals are gathered every year. This could condemn the species to local extinction if we consider, as a reference, a study of one population of *T. punctulata* in Veracruz. Toledo-Aceves et al. (2014) evaluated the effect of harvesting on population maintenance, and found *T. punctulata* to be very close to equilibrium ($\lambda = 0.967$ with confidence intervals of 0.815–1.05); however, their simulated harvesting level of only 2% of individuals resulted in populations becoming locally extinct in less than 40 years. Their study, however, was conducted for a population not among those reported to be harvested by the vendors of Mercado de Jamaica. For *T. deppeana*, with 7,200 individuals gathered yearly, the effect of harvesting could be even more catastrophic, as Winkler et al. (2007) found the population to be already decreasing naturally ($\lambda = 0.85$, CI 0.71–0.98). Again, it is necessary to take into consideration that Winkler et al. (2007) studied a population that was not reported to be harvested by the vendors. Unfortunately, there are no

demographic studies for the other species sold in the Mercado de Jamaica. The demographic studies mentioned for both species of *Tillandsia* were on only one population, and only for a couple of years, so it could be expected that there would be spatial-temporal variation in the λ values. However, all demographic studies of vascular epiphytes show the same tendency (Mondragón et al. 2015).

In addition to the loss of adult individuals per se from the effect of gathering, the harvesting of floral structures represents another threat to the permanence of populations of epiphytic bromeliads: the resulting lack of new seeds that would have allowed not only the establishment of new individuals, but also the continuous colonization of new trees. Colonization would ensure the long-term permanence of these species, given that the availability of substrate for epiphytes is limited by the lifespan of the trees on which they grow (Winkler et al. 2009).

Conclusions

Although the sale of epiphytic bromeliads as cut flowers and foliage is an activity that does not involve many actors or large volumes, it represents a serious threat to the conservation of commercialized plants. The threat arises from the removal of complete reproductive adult individuals, which are key to the functioning of populations; the removal limits the development of seeds needed for colonization of new trees, a fundamental process for the long-term permanence of populations of this type of plant. As most of the tillandsias offered for sale have limited distribution ranges, this loss makes them more vulnerable to extinction. In this regard, the most endangered species, *T. punctulata*, *T. gymnotrya*, and *T. deppeana*, should be prioritized since they are the ones that are gathered the most and are limited to cloud forests, the most vulnerable ecosystem in the country.

Acknowledgments

We thank all informants and vendors for their participation in this work and for their warm hospitality. We also thank Sheeba Sreenivasan for help with English language usage in the paper. This research was funded by Instituto Politécnico Nacional (IPN) SIP20140963. D.M. was supported by a grant from the Comisión de Operación y Fomento de Actividades Académicas, IPN.

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