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Structure and phenology characterization of four tree species of tropical deciduous forests

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ABSTRACT

Objective: To determine the structural and phenological characteristics of four major tree species in the tropical deciduous forests.

Design/Methodology/Approach: To determine their structure, ≥10 cm wide trees were registered at a height of 1.30 m in 30 sites of 500 m^2. For phenological purposes, seven sites were selected. The following phenological stages were evaluated: dormancy, vegetative, flowering, fruiting, and seeding.

Results: Four hundred and five individuals belonging to the four species under study were found: copal ancho (*Bursera copallifera* (Sessé & Moc.) ex DC. Bullock), Mexican kidneywood (*Eysenhardtia polystachya* (Ortega) Sarg.), tecolhuixtle (*Mimosa benthamii* (J.F. Macbr. var. bentha-mii)), and tepemezquite (*Lysiloma divaricatum* (Jacq.) Macbride). Tepemezquite ranked first according to the Relative Importance Value Index. Based on the phenological characteristics observed, three species lost foliage at some time of the year and only tecolhuixtle was evergreen.

Study Limitations/Implications: The results and conclusions are limited only to individuals with ≥10 cm in diameter. Further results can be extrapolated from this data.

Findings/Conclusions: The structural and phenological features of the four species evaluated in ejido El Limón have similar characteristics to those that have been described for this type of vegetation in other locations in Mexico.

Keywords: copal ancho, Mexican kidneywood, tecolhuixtle, tepemezquite.

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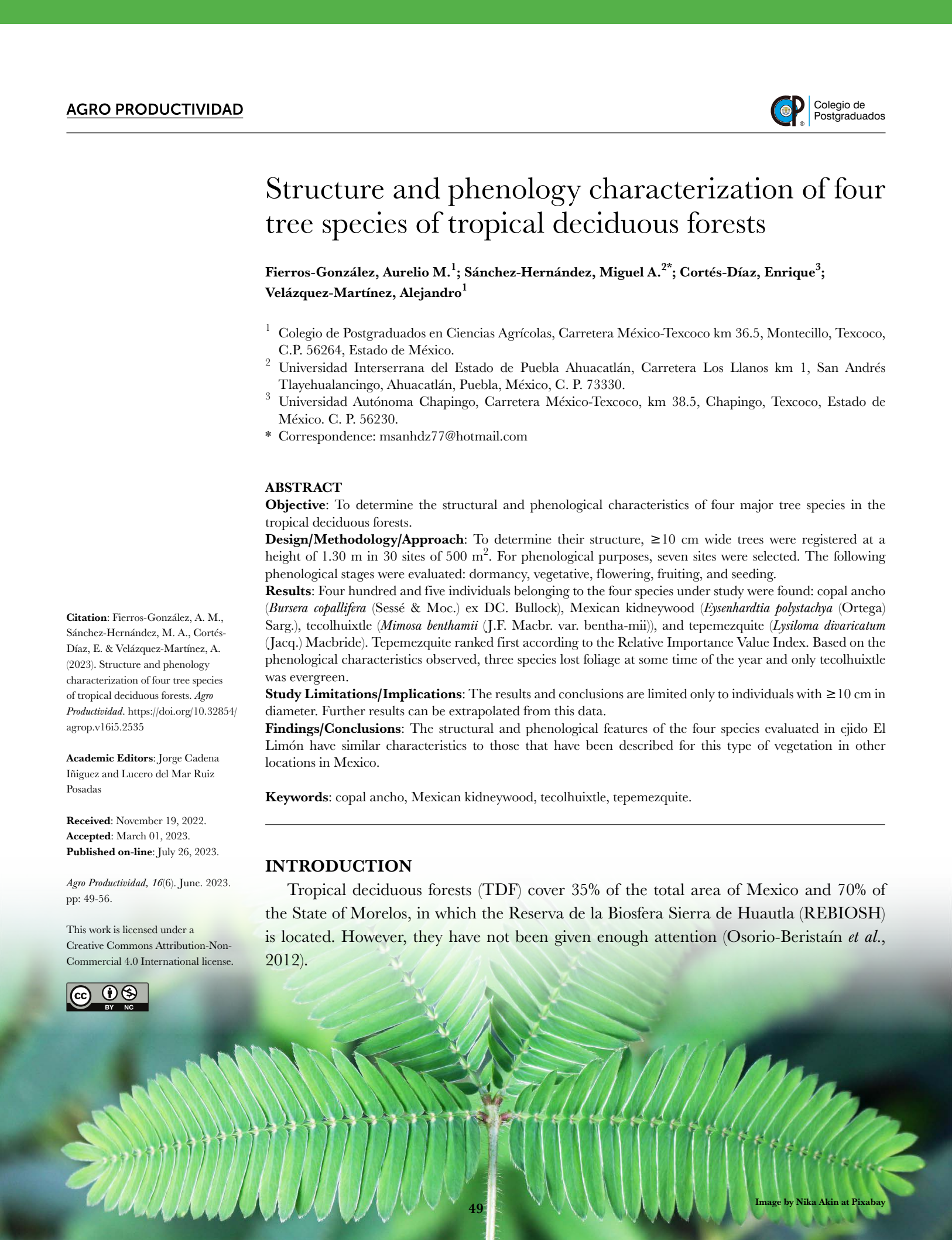
INTRODUCTION

Tropical deciduous forests (TDF) cover 35% of the total area of Mexico and 70% of the State of Morelos, in which the Reserva de la Biosfera Sierra de Huautla (REBIOSH) is located. However, they have not been given enough attention (Osorio-Beristaín *et al.*, 2012).



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The analysis of the structural and phenological characteristics of the tree species of the TDF helps to understand the functioning of this ecosystem and to make informed decisions about its proper management (Graciano-Ávila *et al.*, 2017). Additionally, it is fundamental for conservation programs, forest management, and wilderness management planning (Delgado-Demera *et al.*, 2018). Therefore, the objective of this study was to determine the structural and phenological characteristics of four major tree species in the tropical deciduous forest of the *ejido* El Limón in Tepalcingo, Morelos.

MATERIALS AND METHODS

The study was carried out in the *ejido* El Limón de Cuauchichinola, municipality of Tepalcingo, Morelos. The following species were selected: copal ancho, Mexican kidneywood, tecolhuixtle, and tepemezquite. These species were selected based on their high ecological and social and cultural values.

Structural characteristics

To determine the structural characteristics of the four species, 30 circular sites of 500 m^2 were established, in which ≥10 cm wide trees were registered at 1.30 m from the ground. To obtain the phenological data, the seven sites with the highest concentration were chosen and the phenological stages of the four species were monitored for 12 months. Height was established with a 5-meter GEO-SURV® telescopic levelling rod, model FGTS-5 (individuals ≤ 7 m) and a Suunto® clinometer, model PM5/360PC (trees > 7 m). The horizontal structure was described using the distribution of the number of trees per diameter category, density by species (Zarco-Espinosa *et al.*, 2010), and basal area (BA), which was obtained with the following formula:

$$BA = \frac{\pi}{4000} * D^2$$

Where: BA = basal area; D = Diameter of the tree at 1.30 m above the ground (in centimeters).

The Relative Importance Value Index (RIVI) was calculated through the sum of the relative density (RD), relative dominance (RDom), and relative frequency (RF) (Mostacedo and Fredericksen, 2000).

Phenology

The following phenological stages were observed every two months: dormancy (with foliage), vegetative (without foliage), flowering (number of flowers), fruiting, and seeding- The Fournier (1974) methodology —which consists of applying the scale described in Table 1— was applied.

RESULTS AND DISCUSSION

Four-hundred and five individuals from the four species under study were recorded. The largest number of individuals belonged to tepemezquite (164), followed by tecolhuixtle,

Table 1. Evaluation scale according to the Fournier methodology (1974).

Scale	Description	Range
0	absence of characteristic	0
1	presence of the characteristic, with a magnitude between	1-25%
2	presence of the characteristic, with a magnitude between	26-50%
3	presence of the characteristic, with a magnitude between	51-75%
4	presence of the characteristic, with a magnitude between	76-100%

A figure indicating the percentage of trees observed in each phenological stage was developed to describe the phenology of each species.

copal ancho, and Mexican kidneywood. Table 2 shows the number of individuals per hectare.

None of the four selected species was present in all the sites. The most frequent was tepemezquite, which was found in 83% of the sites. Sixty-three-point-one percent of the total BA of the four species (7.08 m^2 ha^{-1}) was covered with tepemezquite (Table 2). The average height of the four species was 8.7±3.2 m (Table 2).

Three strata categories were differentiated: lower, from 1 to 5.9 m (17% of the individuals); intermediate, 6 to 10.9 m (46%); and upper, 11 to 15.9 m (37%).

In average, the trees in *ejido* El Limón were slightly taller in this study than the trees measured by Guillermo-Sandoval *et al.* (2021) in the same area (average height: 8 m). A similar height (6-8 m) was recorded in different locations in Mexico and the Caribbean islands (Álvarez-Yépiz *et al.*, 2008; Guillermo-Sandoval *et al.*, 2021).

The average diameter per species is shown in Table 2. In the diameter distribution, most of the individuals (78%) measured from 10 to 20 cm, which matches the findings of Gutiérrez-Báez *et al.* (2012), who link this behavior with the age of the community and considers that, as the vegetation of a place recovers, the number of individuals with small diameter decreases; therefore, the community shows a good state of recovery. The average general diameter is 17.3±5.9 cm with an interval of 10 to 45 cm.

Regarding the distribution of individuals by species based on height, copal ancho (75%) and Mexican kidneywood (83%) are distributed mostly in the intermediate stratum, while tecolhuixtle is mainly distributed in the lower stratum (56%), and tepemezquite (59%), mostly in the upper stratum.

Table 2. Number of individuals per hectare, frequency, basal area, height, and average diameter of the four species of the tropical deciduous forests.

Specie	No. Ind. ha^{-1}	Frequency (%)	Basal Area (m^2 ha^{-1})	Average Height (m)	Average Diameter (cm)
Copal ancho	39	53%	1.07	6.7	17.9
Palo dulce	8	17%	0.19	6.5	16.8
Tecolhuixtle	59	40%	1.35	5.02	16.2
Tepemezquite	164	83%	4.47	10.6	17.6
Average				8.7	17.3
Total	270		7.08		

Tepemezquite recorded the highest RIVI and *Eysenhardtia polystachya* had the lowest value (Table 3).

The results match the findings of Hernández-Silva *et al.* (2011) in three *ejidos* of the Sierra de Huautla, Morelos, in which tepemezquite and tecolhuixtle registered a high RIVI, which places them within the first 10 species in this category. However, it is important to point out that they carried out censuses of species without taking the diameter into account.

Vallejo (2009) also carried out a study in the Sierra de Huautla, evaluating the RIVI in different areas: near the foothills, near the smooth hills, far from the foothills, and far from the smooth hills. Vallejo's results showed that tepemezquite is the dominant and most important species in the entire study area, which matches several reports for the TDFs that are distributed along the Pacific coast of Mexico (Pineda-García *et al.*, 2007).

Phenology

In total, 80 trees were monitored. The species with the highest number of individuals was tecolhuixtle (25), followed by copal ancho (22), tepemezquite (21), and Mexican kidneywood (12).

Copal ancho

Flowers were observed in 95.5% of the copal ancho individuals in the first data collection (June 2018) (Figure 1a). Out of this total, 4.5% were found in rank 0 (without flowers), 13.6% in rank 1, 45.5% in rank 2, 27.3% in rank 3, and only 9.1% in range 4, according to the Fournier scale (Figure 1b).

The results of the phenological observations of the second and third survey (August and October 2018) showed that the highest percentage were in the fruiting stage. In December, most of them were already in the seeding stage (81.8%) and some had begun to lose their leaves (9.1%).

In February 2019, 91% of the individuals were dormant; in April, 91% were already in a vegetative stage; and in June all the individuals had some percentage of flowering. Medina-Lemos (2008) determined that the flowering stage lasts from May to June and the fruiting stage goes from June to November, which matches the results of this study.

Mexican kidneywood

In June 2018, 66.7% of the individuals of this species were in a vegetative stage and 33.3% had begun to flower. In August, 75% were in a flowering stage and 25% had begun

Table 3. Relative Importance Value Index (RIVI/IVIR) of the four species.

Specie	Relative Dominance	Relative Density	Relative Frequency	RIVI
Tepemezquite	63.23	60.49	44.0678	167.80
Tecolhuixtle	19.04	21.98	20.33898	61.36
Copal ancho	15.11	14.57	27.11864	56.79
Palo dulce	2.62	2.96	8.474576	14.06

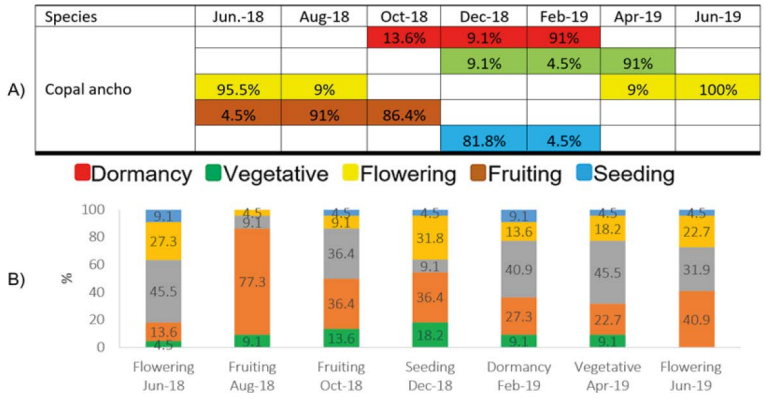

Figure 1. Bimonthly phenological stages from June 2018 to July 2019.

to bear fruits. In October, most of the individuals (83.4%) were at some point of the fruiting range and, in December, 83.3% were in the seeding stage. In February and April 2019, they were in the dormancy stage and, in June, 83.3% were in a vegetative stage (Figure 2a). Figure 2b shows the measurement of phenological characteristics, according to the Fournier scale.

The results of Cervantes-Sánchez and Sotelo-Boyas (2002) are similar to those reported in this study. However, differences can be observed with the datasheets for this species published by Vázquez-Yanes *et al.* (1999), who reported that fruiting occurs from November to December.

Tecolhuixtle

This species did not fully lose its foliage at any time and therefore never entered the vegetative stage. It was not until December 2018 that flowers were observed in 96% of the individuals. In February 2019, 76% of the individuals were already in some point of the fruiting stage; in April, 96% were already in the seeding stage and, in June, the same percentage were dormant (Figure 3).

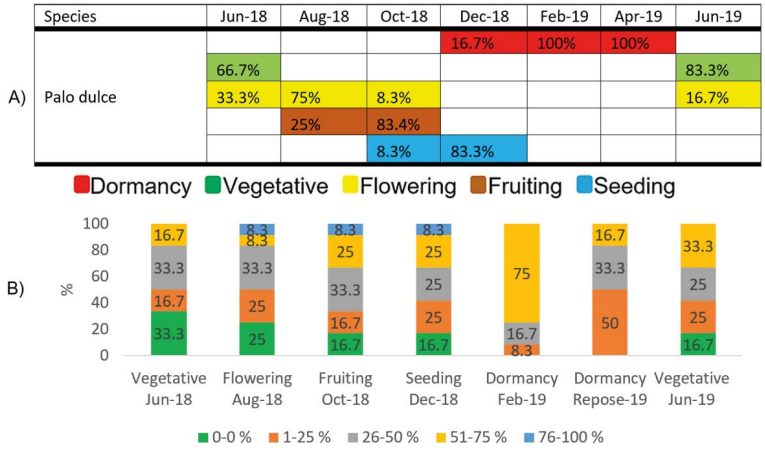

Figure 2. Bimonthly phenological stages from June 2018 to July 2019.

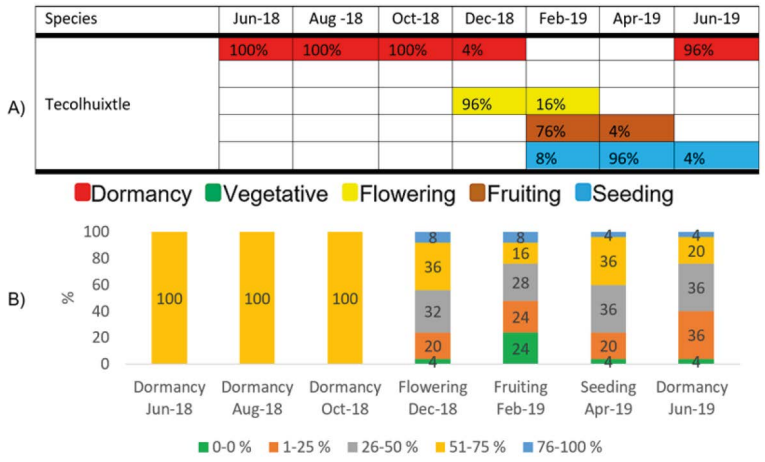

Figure 3. Bimonthly phenological stages from June 2018 to July 2019.

Rico-Arce (2001) reports that this species flowers from September to March and bears fruit from February to June, which matches the results of this study. The reproductive periods of plants are generally associated with water and nutrient availability cycles, as well as climatic factors.

Tepemezquite

Regarding phenology, in June 2018, 90.5% of the individuals were in a vegetative stage and the remaining 9.5% began to flower. In August, 85.7% were already flowering. In October, 90.5% were at some point of the fruiting range, while in December, 95.2% were within the seeding stage. In February and April 2019, most of them were already dormant and, in June, 85.7% of the individuals were in a vegetative stage (Figure 4). The results match the findings of Cervantes-Sánchez and Sotelo-Boyas (2002), who reported that this species usually remains dormant from November to April and enters a vegetative stage from May to October, before it flowers from June to September.

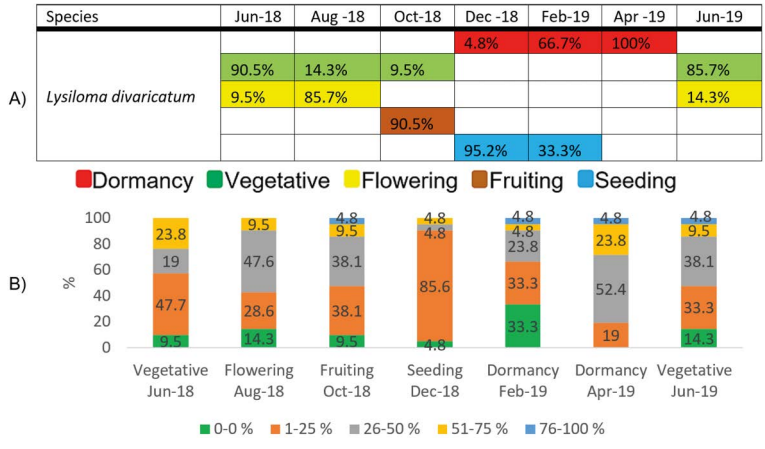

Figure 4. Bimonthly phenological stages from June 2018 to July 2019.

CONCLUSIONS

The structural characteristics of the four woody species analyzed from *ejido* El Limón are similar to what has been described for this type of vegetation in other locations in Mexico.

The most important —due to its structural contribution to the community— and most widely distributed species was Lysiloma divaricatum. This tree has multiple uses (firewood, living fence, or posts), which may favor its use. The quantification of the phenology allows to determine the availability of the fruits and seeds of each site, tree, and species.

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