Expanding description and taxonomic aspects of Heliopsis longipes (Asteraceae: Heliantheae)

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Abstract

Heliopsis longipes is, economically, the most important species of its genus, because its root has several traditional uses in Mexico. However, there are still unknown aspects of their morphology and biology. The objectives of this study were: a) to expand the botanical description of the species, b) to discuss the differences of H. longipes with some congeners, c) to document their phenology. Heliopsis longipes has an ascending to decumbent habit, ovate-oblong leaves and the stem is relatively long and it is microendemic in Sierra Alvarez and Sierra Gorda. Morphologically, it has more affinities with H. procumbens. The reproduction of H. longipes occurs during the wet season of the year.

Key words: Asteraceae, chilcuague, botanical description, phenology, Heliopsis longipes.

Introduction

Heliopsis is a genus in the tribe Heliantheae of the Asteraceae family, and it is distinguished by the fact that both types of flowers, ray and disc flowers, are hermaphroditic and fertile. The ray flowers are withered and sessile, and the achenes of both types of flowers are thick, three- or four-angled, with the pappus either absent or very reduced (Fisher, 1954, 1957; Rzedowski and Calderón, 2008). Rzedowski and Calderón (2008) also add that the leaf margins are generally serrated or crenate, and the involucre is not noticeably graduated. The genus is American, with 32 species (International Plant Name Index, 2012). Of these, 11 are exclusive to Mexico (H. anomala B.L. Turner, H. annua Hemsl., H. brachactis Standl. ex Fisher, H. filiformis S. Watson, H. longipes S.F. Blake, H. novogaliciana B.L. Turner, H. parviceps S.F. Blake, H. procumbens Hemsl., H. rubra Fisher, H. sinaloensis B.L. Turner, and H. suffruticosa Ramírez-Noya et S. González) and two are distributed from Mexico to the south of the continent (H. buphthalmoides Dun. and H. parvifolia A. Gray) (Little, 1948a; Paray, 1954; Fisher, 1954, 1957; Turner, 1987; García-Chávez et al., 2004; Ramírez-Noya et al., 2011).

In 1753, Linnaeus described the species *Buphthalmum helianthoides* L., *Silphium solidaginoides* L., and *Rudbeckia oppositifolia* L. In 1807, C.H. Persoon described the genus Heliopsis and renamed the three Linnaean species as *Heliopsis laevis* Pers. (Fisher, 1954). The inclusion and exclusion of specific entities in Heliopsis have been the subject of

prolonged debate, carefully recorded and analyzed by Fisher (1954, 1957) and Turner (1987, 1988).

Heliopsis longipes is a microendemic species of the Sierra de Álvarez and Sierra Gorda in the states of San Luis Potosí, Guanajuato (Cilia et al., 2007a), and Querétaro (Rzedowski and Calderón, 2008). It is the species with the greatest economic importance in its genus (Cilia-López et al., 2008), and its root has traditional uses as a condiment, medicine, and insecticide (Martínez, 1936, 1955; Little, 1948a; Cilia-López et al., 2008). An alkamide isolated from the root of *H. longipes*, named affinin, has been attributed with traditionally known insecticidal properties (Acree et al., 1945a,b; Jacobson et al., 1947). Phytochemical studies have been conducted on *H. longipes* and the affinin present in its root (Molina-Torres et al., 1995, 1996; García-Chávez et al., 2004; Cilia-López et al., 2009) as well as pharmacological studies (Gutiérrez Lugo et al., 1996; Molina-Torres et al., 1999; Ramírez-Chávez et al., 2000; Acosta-Madrid et al., 2009; Cilia-López et al., 2009; Cariño C. et al., 2010).

With specimens collected in San Luis Potosí by C.C. Perry and E. Palmer in 1878, A. Gray described *Philactis longipes* A. Gray. In 1924, S.F. Blake, based on the plant's habit, involucre characteristics, fertile ray flowers, and absence of pappus in the achenes, transferred *Philactis longipes* to the genus *Heliopsis*. Acree et al. (1945a) obtained roots of chilcuán by correspondence, supposedly collected from localities near Mexico City. These roots were sent to them and identified as belonging to *Erigeron affinis* DC. (currently *E. longipes* DC.). It is likely that the confusion arose because the suppliers of Acree obtained the roots under the name chilcuán and, upon consulting Martínez's (1936) work, identified them as *E. affinis*. Due to the absence of herbarium specimens and the need to confirm or correct the species name, E.L. Little conducted a botanical exploration in the Sierra Gorda, San Luis Potosí, where he collected specimens of *chilcuán*, which were reviewed by S.F. Blake, who confirmed its correct name as *Heliopsis longipes* (Little, 1948a, 1948b).

According to Fisher (1954, 1957), *H. longipes* and *H. buphthalmoides* are morphologically similar species, sharing orbicular or ovate-lanceolate leaves and peduncles measuring 9-20 cm. Fisher noted that the primary difference is that *H. longipes* generally has smaller leaves, flower heads (never larger than 1 cm), and overall plant size. Additionally, he pointed out that the distribution of *H. longipes* is restricted to San Luis Potosí.

Despite its economic and scientific importance, *H. longipes* was sparsely collected and underrepresented in herbariums until about a decade ago (Rzedowski, 1955; Salazar, 1999). The available botanical descriptions of the species are brief (Blake, 1924; Fisher, 1954, 1957; Salazar, 1999), with slightly more detailed descriptions provided by Rzedowski and Calderón (2008). However, important data have been omitted, such as the quantity and dimensions of the roots, distribution of pubescence on young stems, number of internodes, phyllotaxy, petiole thickness, dimensions of the flower heads, and dimensions of the involucre, among others. Additionally, more precise data are required regarding its biology, particularly its phenology.

Therefore, the objectives of this work were: a) to expand the botanical description of *H. longipes* based on newly collected specimens, b) to discuss the morphological differences between *H. longipes* and its closest congeners, and c) to document its phenology.

Material and Methods

Botanical explorations were conducted in the Sierra Gorda and Sierra de Álvarez regions in San Luis Potosí (Table 1), where nine localities with healthy wild populations of *Heliopsis longipes* under sustainable use were identified. In each locality, adult individuals were collected, aiming to capture the full phenotypic variability observed and reported in the literature.

Table 1. Localities in the Sierra Gorda and Sierra de Álvarez, in the municipality of Rioverde, SLP, where samples of *Heliopsis longipes* were collected.

Locality	Latitude north	Longitude west	Altitude (m)
Las Márgaras	21° 48’	100° 11’	1760
El Pescadito	21° 48’	100° 02’	1795
Cuchilla Alta	21° 46’	100° 09’	1620
Huertitas	21° 46’	100° 09’	1760
Las Albercas	21° 45’	100° 11’	1780
La Alameda	21° 40’	100° 11’	1690
Cerro del Terán	21° 40’	100° 10’	1660
Rincón de los Jabalines	21° 40’	100° 10’	1640
La Caña	21° 38’	99° 55’	1690

To systematically record the morphological information, a descriptor was developed based on a review of identification keys for Asteraceae genera (Rzedowski, 1978; McVaugh, 1984), the description of the genus *Heliopsis* (Fisher, 1954; Rzedowski & Calderón, 2008), and descriptions of *H. longipes* (Gray, 1879; Blake, 1924; Fisher, 1954, 1957; Salazar, 1999; Rzedowski & Calderón, 2008). The descriptor was refined through a review of specimens deposited in the MEXU and SLPM herbaria. A less commonly described organ in botanical descriptions, the root, was detailed in terms of its type, quantity, length, and thickness, as it is of economic interest (Cilia-López et al., 2008). A photograph of the type specimen was accessed for comparison.

The best locality for recording the phenological events of *H. longipes* was Huertitas (Table 1), due to its isolation, minimal exploitation, and low environmental degradation. Additionally, the local chilcuague harvester from the area committed to protecting the site during the year of observation. The locality is representative of the distribution area of chilcuague (Cilia-López et al., 2007a), with a C(w0) climate, the driest of the temperate climates, with summer rainfall (García, 2004). The average annual temperature is 18°C, and the average annual precipitation is 700 mm. According to the nearest weather station (20°04'N, 100°27'W, and 1980 meters above sea level), the region experiences a wet season from June to September, a dry-cold season from October to February, and a dry-warm season from March to May. The surface lithology is mainly igneous, with some sedimentary areas, and the vegetation consists of oak and oak-pine forests (Salazar, 1999).

Monthly visits were conducted from October 2004 to November 2005. While the main phenological observations were made in Huertitas, phenological events were also confirmed in other localities. To record the phenological stages, 100 plants were randomly selected and marked. The stages of the vegetative period were defined based on the criteria of Castillo and Carabias (1982), and the reproductive stages were defined according to Figueroa et al. (1998). The phenological stages recognized and recorded were: vegetative stage (production

of leaves and stems), appearance of reproductive structures (floral bud), anthesis of ray and disc flowers, presence of achenes (fruiting), and loss of foliage (defoliation).

Results

Heliopsis longipes (A. Gray) S.F. Blake**,**
Contr. U.S. Nat. Herb**.**, 22: 608. 1924**.**
Philactis longipes A. Gray, Proc. Amer. Acad. Sci., 15: 35, 1879.

Type: San Luis Potosí, Mexico, 1829-2438 m a.s.l., C.C. Parry and E. Palmer 465 (Royal Botanic Gardens, Kew, K, K000502143).

Heliopsis longipes is a perennial herbaceous plant, semi-woody, ranging from 19.6 to 38.9 cm in height, with 11-33 fibrous, rhizomatous, fleshy roots measuring 22.3-38 cm in length and 0.9-4.1 mm in thickness. The plant has 1-7 stems, 15-27 cm in length, and 1.3-1.9 mm (up to 4 mm) in diameter. The stems are striated, herbaceous, reddish-purple, somewhat woody at the base, and ascend to become decumbent or subdecumbent. Younger stems have a hirsute base with pubescent upper parts, while mature stems are glabrous at the base, with puberulous-scruffy tomentum from 6.6 to 14 cm in height, and 3-8 nodes with internodes measuring 2.1-4.7 cm (up to 5.5 cm).

The leaves are opposite, with strigose petioles 3.9-6.2 mm in length and 1.4-2 mm in diameter. The leaf blades are ovate to oblong or sometimes lanceolate, ranging from 2.6-4 cm (up to 5 cm) in length and 1.6-2.9 cm (up to 3.5 cm) in width. The apex is submucronate, ranging from obtuse to acute, with a truncated to cuneate base. The margins are serrated, slightly dentate, or almost entire near the apex. The leaves are dark green, membranous, pilose-strigose on the upper surface, and paler with less dense pubescence on the underside.

The flower heads are terminal and solitary, 1-3 per plant, measuring 2.8-4.2 cm in height and 0.8-1.4 cm in diameter. They are borne on long peduncles, 9.9-25 cm (up to 30 cm) in length and 1.2-1.7 mm in diameter, striated, and sparsely pubescent at the base with denser pubescence towards the top. The involucre is broadly turbinate to almost hemispherical, 1.3-1.9 mm tall and 9.3-11 mm in diameter, with 6-10 subequal bracts arranged in two series. Each bract is lanceolate, ovate, or obovate, measuring 8.4-10.4 mm in length and 2.9-4.2 mm in width, obtuse to acuminate at the apex, densely pubescent on the outside and glabrous on the inside.

The receptacle is conical, becoming columnar in mature flowers, and is covered with linear-lanceolate paleas, which are acuminate, measuring 4.8-6 mm (up to 7 mm) in length and 0.8-1.2 mm in width, yellow-brown, and glabrous. The ray flowers number 5-11, yellow, hermaphroditic, with linear to oblong-elliptic blades measuring 15.2-20.5 mm in length and 5.4-7.4 mm in width, sparsely pubescent to puberulous on the outside, with a three-toothed apex. The disc flowers number 40-176, are hermaphroditic, with tubular, yellow-brown corollas measuring 4.7-5.6 mm in length and 1-1.3 mm in width. The corolla has five teeth, with blackish anthers measuring 1.5 mm in length, sometimes with an obtuse base, and the style branches are flattened, blunt, and penicillate at the apex.

The achenes of the ray flowers measure 3.1-4.5 mm in length and 1.4-2.5 mm in width, quadrangular, striated, green to brown. The achenes of the disc flowers are 2.6-3.9 mm long and 1.2-2.9 mm wide, triangular or quadrangular, muricate, striated, and brown to blackish-brown. The pappus is absent or sometimes consists of 2-4 small, membranous awns.

Heliopsis longipes is microendemic to the border regions of the states of San Luis Potosí, Guanajuato, and Querétaro, found between latitudes 21°50'N and 20°55'S, and longitudes 99°37'E and 100°25'W. It inhabits steep canyons with oak (*Quercus*) and pine-oak (*Pinus-Quercus*) forests. The dominant tree species in these forests are *Pinus pseudostrobus* Lindley, *P. teocote* Schiede ex Schltdl. & Cham., *Quercus affinis* Scheidw., *Q. castanea* Née, *Q. crassifolia* Humb. & Bonpl., *Q. laeta* Liebm., and *Q. obtusata* Humb. & Bonpl. Subdominant tree species include *Prunus serotina* Ehrh. and *Arbutus xalapensis* Kunth. In the shrub layer, *Rhus aromatica* Aiton dominates.

Most of the populations (75%) of *H. longipes* were found on igneous geological substrates, with the rest on sedimentary substrates, primarily limestone, as also recorded by Salazar (1999). The soil types in these areas are lithosols, pheozems, or luvisols, covered with a deep layer of leaf litter.

Examined Material:

MEXICO, San Luis Potosí:

- **Las Márgaras** 21°48’N 100°11’W, 1760 m, Cilia 116, 42501 (SLPM);
- **El Pescadito** 21°48’N 100°02’W, 1795 m, Cilia 114, 42502 (SLPM);
- **Cuchilla Alta** 21°46’N 100°09’W, 1620 m, Cilia 115, 42503 (SLPM);
- **Huertitas** 21°46’N 100°09’W, 1760 m, Cilia 117, 42504 (SLPM);
- **Las Albercas** 21°45’N 100°11’W, 1780 m, Cilia 113, 42505 (SLPM);
- **La Alameda** 21°40’N 100°11’W, 1690 m, Cilia 110, 42506 (SLPM);
- **Cerro del Terán** 21°40’N 100°10’W, 1660 m, Cilia 109, 42507 (SLPM);
- **La Caña** 21°38’N 99°55’W, 1690 m, Cilia 119, 42508 (SLPM).

The reproductive phase of *Heliopsis longipes* occurred during the wet season. The first floral buds were observed in late June, and the anthesis of the ray flowers and disc flowers was recorded between July and August, respectively. The fruiting period began at the start of the dry-cold season (October to February), and in the middle of this season (December-January), the achenes of the ray flowers dispersed first, followed by the achenes of the disc flowers.

During the dry-warm season (March to May), 60-80% of the population lost its foliage, likely due to limited water availability. Vegetative organ production was observed almost year-round, but during the wet season, 43% of the population exhibited this phenological state, producing stems and leaves. In contrast, only 19.02% of the population was in this state during the dry-warm season, primarily producing leaves (Fig. 2).

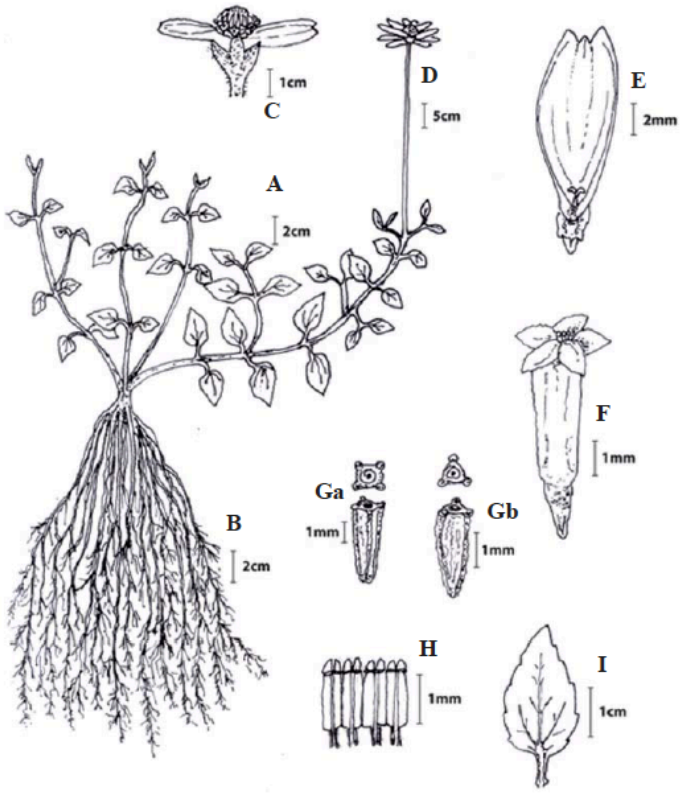

Fig. 1. *Heliopsis longipes* A. Hábito. B. Raíz. C. Cabezuela. D. Pedúnculo. E. Flor ligulada. F. Flor del disco. Ga. Aquenio de flor ligulada. Gb. Aquenio de flor del disco. H. Estambres. I. Hoja (Cilia 117 SLPM).

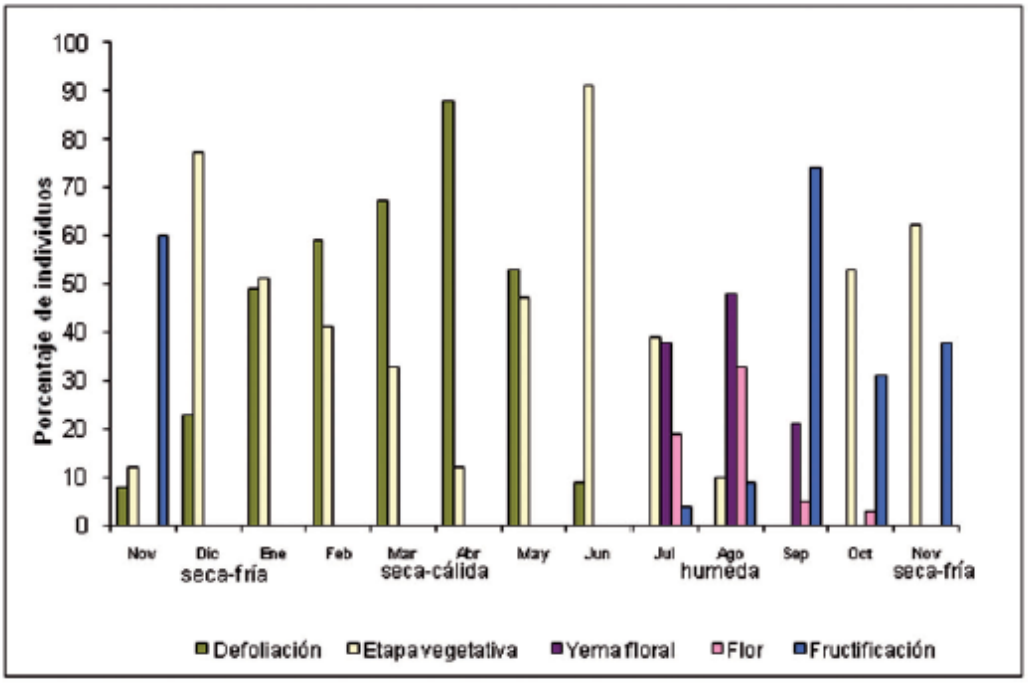

Fig. 2. Phenology of Heliopsis longipes recorded in the town of Huertitas, Rioverde, S.L.P., Mexico

Species	Habit	Height (cm)	Leaf shape	Leaf size (cm)	Peduncle size (cm)	Distribution
H. longipes	Ascending to decumbent or sub-decumbent	19.6-38.9	Ovate to oblong	Length: (1-)2.6-4(-5) Width: (1-)1.6-2.9(-3.5)	(9-)9.9-25(-30) Length	Mexico: San Luis Potosí, Guanajuato, Querétaro
H. procumbens	Ascending, sub-erect or decumbent	20-25	Orbicular, ovate-lanceolate, or oblong	1.3-5 Length	8-25 Length	Mexico: Michoacán, Jalisco, Mexico State, Morelos, and surrounding regions
H. parvifolia	Erect	30-40	Deltoid, lanceolate, or ovate	Length: 2-3.5	8-25	USA: California, Arizona, New Mexico, Texas
H. buphthalmoides	Erect	50-75 (up to 200)	Ovate to lanceolate, sometimes deltoid	Length: 10-14, Width: 2.5-4.5	10-20 Length	Colombia, Venezuela, Peru, Bolivia

Table 2. Comparison of Heliopsis longipes with its morphologically similar congeners.

Discussion

The consulted authors agree on the distinctive characteristics of the genus, but Rzedowski and Calderón (2008) add that the leaf margins are serrated or crenate, and the involucre is not conspicuously graduated. Fisher (1957) mentions that the most frequent leaf margins are irregularly toothed and notes that the involucre is highly variable in shape, size, and pubescence.

The life form of *Heliopsis longipes* is commonly described as a perennial herb (Blake, 1924; Fisher, 1954, 1957; Salazar, 1999; Rzedowski & Calderón, 2008). However, Salazar (1999) and Rzedowski & Calderón (2008) mention that the stems are somewhat woody at the base, a characteristic confirmed in the field. Therefore, the term "suffruticose" is added to its life form, as Fon-Quer (1953) defines it as a plant "barely lignified at the base."

Fisher (1954) noted the presence of oblong-lanceolate to elliptical leaves in his description of *H. longipes*, and in his dichotomous keys, he describes them as orbicular or ovate-lanceolate, as seen in the type specimen photograph. Rzedowski & Calderón (2008) describe them as ovate to lanceolate. However, in this study, lanceolate, orbicular, or elliptical leaves were not observed. The linear-oblong ray flowers, yellow to brown disc flowers, and achenes with a diminutive pappus, as mentioned by Fisher (1954), were also not observed in the examined specimens, nor were they included by Rzedowski & Calderón (2008). These discrepancies with Fisher's description may be due to the fact that he only examined three herbarium specimens (Fisher, 1954:186).

According to Villaseñor (pers. comm.), there is taxonomic confusion between *H. longipes* and *H. buphthalmoides*, *H. parvifolia*, and *H. procumbens* (Table 2). Indeed, the first three species are adjacent in Fisher's (1954) taxonomic keys, as well as *H. longipes* and *H. procumbens* in the keys of Rzedowski & Calderón (2008). These confusions arise partly from morphological similarities and also from the lack of clear and detailed descriptions for each species. However, *H. buphthalmoides* and *H. parvifolia* are taller, their leaves are deltoid, lanceolate, or ovate, and they have petioles longer than 0.8 cm, with larger leaves in both length and width (Table 2). On the other hand, *H. longipes* and *H. procumbens* are shorter, have short petioles, and their leaves are never deltoid (Table 2). Despite the similarities between these two species, *H. longipes* tends to be taller than *H. procumbens*, and the leaves of *H. procumbens*, lanceolate to ovate, can be sessile or have shorter petioles and smaller

blades than those of *H. longipes* (Table 2). Fisher (1954) mentioned that creating a key for *Heliopsis*, in which the specimens can be properly placed, is extremely difficult. Indeed, attempts to create a dichotomous key for these four species were unsuccessful due to overlapping morphological traits. Thus, the most distinct characteristic for differentiating them is their distribution: *H. longipes* is microendemic to the Sierra de Álvarez and Sierra Gorda (Cilia-López et al., 2007a), while *H. procumbens*, absent from this region, has a broader distribution. Fisher (1957) places it from central Mexico to the western part of the country and Sinaloa, and Rzedowski & Calderón (2008) mention it as endemic to central-western Mexico. The other two species, *H. buphthalmoides* and *H. parvifolia*, have even wider distributions, excluding the area of *H. longipes* (Table 2).

The phenological information obtained coincides with the observations of Little (1948b), although he does not mention that vegetative growth occurs almost year-round, though at varying intensities. The production of vegetative organs and reproduction during the rainy season suggests that humidity is the most important factor for *H. longipes*. Live specimens growing in the gardens of the Desert Research Institute of the Autonomous University of San Luis Potosí (UASLP), which receive moderate moisture year-round, continue to grow and flower throughout the year. The reproductive period of *H. longipes* recorded in this study aligns with the observations for perennial species of the genus *Heliopsis* (Fisher, 1954).

Previous studies lack observations or evidence of asexual reproduction in this species; however, during the study period, it was observed that *H. longipes* can multiply from stems that produce roots, which are described as rhizomes by Rzedowski & Calderón (2008), at the stem nodes in contact with the soil, particularly during the wet and dry-cold seasons. In contrast, no germination or seedling presence was observed at any time, suggesting limitations for its natural repopulation through sexual means. Reproduction and propagation were tested in laboratory conditions, and it was found that seeds less than one year old have a viability of 94% and a germination rate of up to 90% (Cilia-López et al., 2007b). Therefore, the apparent absence of seedlings in the field may be related to the accumulation of leaf litter in the mature sites studied. In terms of propagation, the most suitable stem thickness for promoting regrowth was found to be 3.0 mm in diameter (Cilia-López et al., 2007b). Since the traditional harvesting of this species involves the total destruction of the plant, as root collectors discard the shoots, and since in its natural environment *H. longipes* reproduces mainly asexually or vegetatively through stems, the discarded shoots during root harvesting could be used to promote its propagation and thus support the persistence of wild populations of this species (Cilia-López et al., 2007b).

Conclusions

Heliopsis longipes is distinguished from its closely related species by its ascending to decumbent habit, ovate to oblong leaves, and relatively long peduncles. Morphologically, it is most similar to *H. procumbens* but differs in its greater height, longer petioles, and larger leaves and peduncles. Additionally, *H. longipes* has a restricted distribution in the Sierra de Álvarez and Sierra Gorda, whereas *H. procumbens* has a distinct and broader distribution. The reproductive season of *H. longipes* occurs during the wet season, which is common for perennial species of the genus *Heliopsis*. The apparent absence of seedlings in the understory is likely related to successional aspects. The discarded shoots during root harvesting could be used to promote its propagation and thus support the persistence of wild populations of this species.

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