



Salvia semiscaposa (Lamiaceae) a new species from Nanchititla, Mexico

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Abstract

A new species of *Salvia* section *Lavanduloideae* from the Estado de México is described and illustrated. *Salvia semiscaposa* is a procumbent plant morphologically similar to *S. scaposa* and *S. helianthemifolia*. It differs from the former by having mostly obovate leaf blades, more than six flowers per verticillaster and posterior calyx lobes narrower and apiculate. On the other hand, *S. helianthemifolia* differs from the new species by the presence of an erect stem, ovate leaves and trichomes on the calyx surface distributed only on the veins.

Resumen

Se describe e ilustra una nueva especie de *Salvia* sección *Lavanduloideae* del Estado de México. *Salvia semiscaposa* es una planta procumbente morfológicamente similar a *S. scaposa* y *S. helianthemifolia*. De la primera difiere por presentar generalmente hojas obovadas, más de seis flores por verticilastro y lóbulos posteriores del cáliz más estrechos y apiculados. Por otro lado, *S. helianthemifolia* difiere de la especie nueva por la presencia de un tallo erecto, hojas ovadas y tricomas del cáliz presentes solamente en las venas.

Key words: multivariate analyses, *Calosphace*, geometric morphometrics

Introduction

Salvia Linnaeus (1753: 23) is the second most diverse genus in Mexico (Villaseñor 2004), with more than 300 species, of which 75% are endemic (Martínez-Gordillo *et al.* 2013). These numbers are continuously growing, as more species had been recently described by Klitgaard (2007), Turner (2008, 2013), Bedolla-García *et al.* (2011), Martínez-Gordillo & Lozada-Pérez (2011), González-Gallegos *et al.* (2012a, 2012b, 2013), Iltis *et al.* (2012), Fragoso-Martínez & Martínez-Gordillo (2013), González-Gallegos (2013), González-Gallegos & Castro-Castro (2013), González-Gallegos & Aguilar-Santelises (2014) and Lara-Cabrera *et al.* (2013).

Phylogenetic studies based on molecular data suggest that *Salvia* is paraphyletic and that only the Neotropical subgenus *Calosphace*, is monophyletic (Walker *et al.* 2004). *Calosphace* is the most species-rich subgenus of *Salvia* with ca. 600 species (Epling 1939, Santos 1995). The countries that hold most of the diversity of *Calosphace* are Mexico (310 spp.; Martínez-Gordillo *et al.* 2013) and Peru (81 spp.; Zarucci 1993). The Neotropical sages are distributed mainly along the mountain chains of Mesoamerica and South America, being especially diverse in montane tropical forests (Espejo & Ramamoorthy 1993). In Mexico the endemism of *Salvia* subgenus *Calosphace* is high in the Sierra Madre Oriental, Sierra Madre Occidental, and Trans-Mexican Volcanic Belt (Ramamoorthy & Elliot 1998).

The great diversity of *Calosphace* has been classified in more than 100 sections (Epling 1939, 1940, 1941, 1947, 1951, Epling & Játiva 1966, Ramamoorthy 1984a, Ramamoorthy & Elliot 1998). *Salvia* section *Lavanduloideae* Epling (1939: 34) is a group of 12 species endemic to Mexico, except *Salvia lavanduloides* Kunth (1817: 287), which has been

reported also from Guatemala to Costa Rica (Klitgaard 2012). This group includes herbaceous perennial plants, with 3-veined posterior calyx lobes, stamens included in the galea and a concave anterior stigmatic branch (Epling 1939). The only revision available for *Lavanduloideae* is the one of Epling (1939), where the section was first described. Later, Epling described three new species but these were never validly published. One species is indeed different to all known in section *Lavanduloideae*, which is now described and validated here with the name given originally by Epling. The new species is similar to *S. scaposa* Epling (1939: 35) and *S. helianthemifolia* Benth (1833: 254), thus we present a morphometric analysis, which helps to differentiate these species.

Materials and methods

Herbarium work

On December of 1954 in an expedition conducted by the Commission of botanic explorations of the Estado de México, Eizi Matuda collected specimens of a scapose-like sage from Sierra de Nanchititla. Epling, in an unpublished manuscript, recognized one of these specimens (*Matuda 31980*) as the type of a new species. The specimen remained in the collection of MEXU herbarium identified erroneously as *Salvia remota* Benth (1848: 304). To verify the locality of the new species and to collect additional specimens for the description, two expeditions to Sierra de Nanchititla were made in the years of 2011 and 2012. For the new species we retrieved distribution and morphological data from a total of 17 specimens from the collections at FCME and MEXU herbaria.

Geometric morphometrics

A morphometric comparison of shapes of leaves was undertaken to differentiate the new species from two morphologically similar species: *S. scaposa* and *S. helianthemifolia*, and also its sister species: *S. rzedowskii* Ramamoorthy (1984b: 139). Digital images were acquired from ten specimens of the new species (21 leaves), 14 specimens of *S. helianthemifolia* (33 leaves), 15 specimens of *S. rzedowskii* (28 leaves) and 28 specimens of *S. scaposa* (58 leaves), all including a ruler for scale. The leaf blades were photographed from the herbarium sheets laying flat under a digital camera (Olympus Camedia c-740 U or a Canon EOS Digital Rebel 6M) fixed on a Bencher copy stand. Digital photography was achieved with equipment available at the Laboratorio de Morfometría, Instituto de Ecología (INECOL) and at the Laboratorio de Microcine, Facultad de Ciencias (UNAM).

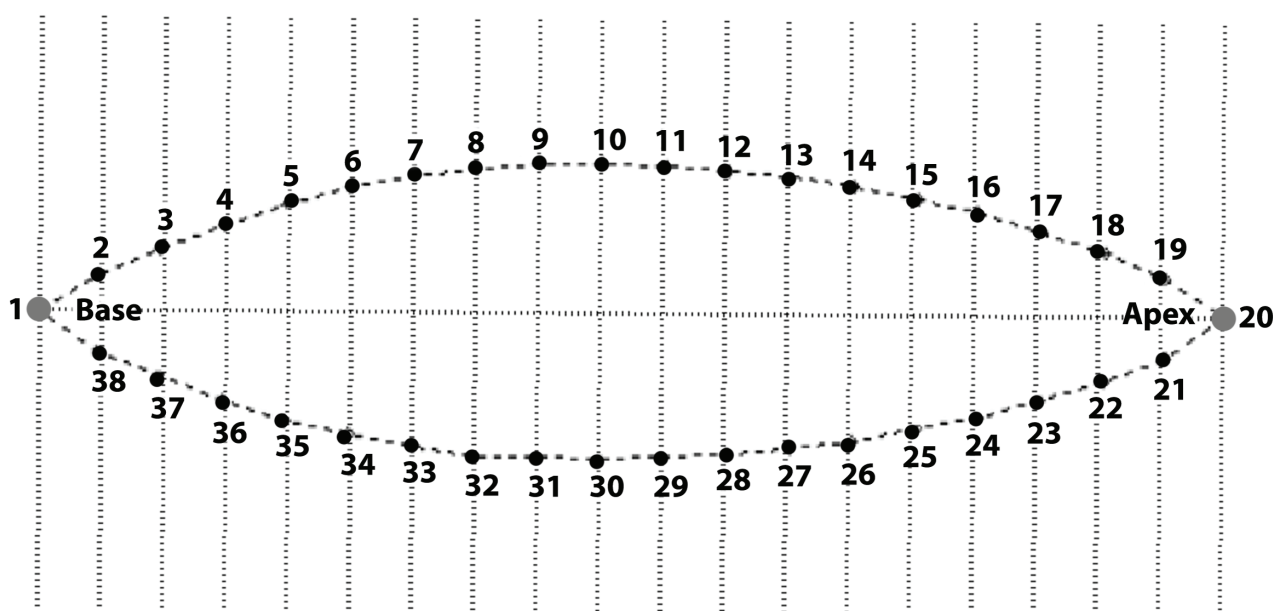


FIGURE 1. Landmarks (gray) and semi-landmarks (black) selected to describe the shape of the leaf blade using a comb with 20 rays.

The shape of the leaf blades was registered with strings of semi-landmark points. We used a comb of 20 rays as a graphical tool to place the same number of points along a curve segment (Sheets 2004a). Combs were added to the photographs using MakeFan6 from the IMP series (Sheets 2004b). The shape of the leaf blades was sampled with a configuration of 38 points: two landmarks (base and apex) and 36 semi-landmarks (Fig. 1).

Two dimensional landmark configurations were digitized in tpsDig 2.16 (Rohlf 2010). The x, y coordinates were processed and analyzed with different programs from the IMP series (Sheets 2004b). Procrustes superpositions were carried out in CoordGen and semi-landmarks were slid in SemiLand. Comparison of shapes among the new species, *S. rzedowskii*, *S. helianthemifolia* and *S. scaposa*, as a priori groups, was performed by canonical discriminant analysis of the partial warp scores (PWs) using the CVAGen6 program (<http://www2.canisius.edu/~sheets/morphsoft.html>) developed by Sheets (2004b). Our question was whether there is a difference among the four average shapes of the species, as a priori groups. The tests of significance of the canonical variate axes were based on the Wilks's lambda value. The CVA scores obtained on CVAGen6 were plotted using the packages e1071 (Meyer *et al.* 2014) and ggplot (Wickham 2009) in R (R Core Team 2014).

Taxonomy

Salvia semiscaposa Epling ex Fragoso & Mart.Gord. *sp. nov.* (figs. 2, 3)

Salvia scaposae affinis sed foliis subsessilis, ovatis obovatis ad medium attenuatum usque ad basim, corollae infero labio longiore.

Type:—MEXICO. Estado de México, por la carretera a Cañadas de Nanchititla, cerca de 6 km al W, antes de la desviación al parque, 1765 m, 18°52'46.3"N, 100°23'13.8"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 17* (holotype FCME!, isotype MEXU!).

Decumbent perennial herbs; 0.5–1 m tall, with several stems arising from a woody caudex; stems appressed-hirsute; internodes shortened towards the base, 1.5–8.5(–10) cm long. Leaves developed towards the base, subsessile, petioles 0.1–0.7 cm long, appressed-pubescent; basal leaf blades ovate, upper leaf blades obovate, 2.5–8 × 1–2 cm, apex obtuse, base attenuated, margin crenate, both surfaces appressed-hirsute, lower surface pale. Inflorescences terminal, spiciform, simple or in fascicles of three, sometimes the inflorescence can be secund; peduncles 2–10.5 cm long; spikes 4–15(–20) cm long, verticillasters 0.5–2 cm apart. Bracts minute, 1.5–3.5 × 0.9–1.2 mm, foliaceous, ovate, deciduous early at the development of the inflorescence. Flowers 6–10 per whorl, pedicels 2–5 mm long, divaricate to reflexed, appressed-hirsute. Calyx bilabiate, purple, tube 3.5–5 mm long, appressed-hirsute; calyx lobes obtuse-apiculate, posterior lobe 3-veined, slightly shorter than the anterior ones, lobes 1.5–2.5 mm long. Corolla lilac or purple, tube straight, same size or slightly longer than the calyx tube, 5.5–7 mm long; posterior lobe of the corolla galeate, with the external surface pubescent, 2–3 mm long; anterior lobe 5–7(–8) mm long, reflexed. Stamens included; filaments 1.2–2.4 mm long; connectives 1.5–2 mm long, with an acute ventral tooth; thecae 0.75–1.5 mm long. Style 7.5–9.5 mm long, pubescent near the branches, anterior branch rounded at the tip and concave; posterior branch curled backward, longer than the anterior. Mericarp ovoid, smooth, 1.5–2 mm long.

Distribution and habitat:—*Salvia semiscaposa* is endemic to Mexico and is known only from the Sierra de Nanchititla, Estado de México, near the state limits with Guerrero and Michoacán (Fig. 4). This mountain range extends to Guerrero, where this species might inhabit as well. It has been collected in oak forests, pine-oak forests, and xeric shrub lands, usually found on moderately exposed slopes, occurring at 650–2000 m elevation. In all the localities visited, the abundance of this species was moderate to high.

Phenology:—Flowering and fruiting from September to January.

Etymology:—“*semiscaposa*” is the epithet that Epling assigned to this taxa on his unpublished manuscript, it is related to the habit of the plant, which is not entirely scapose because the stems are long but decumbent (Figs. 2A, 3A), conversely to the erect stems in *Salvia scaposa*.

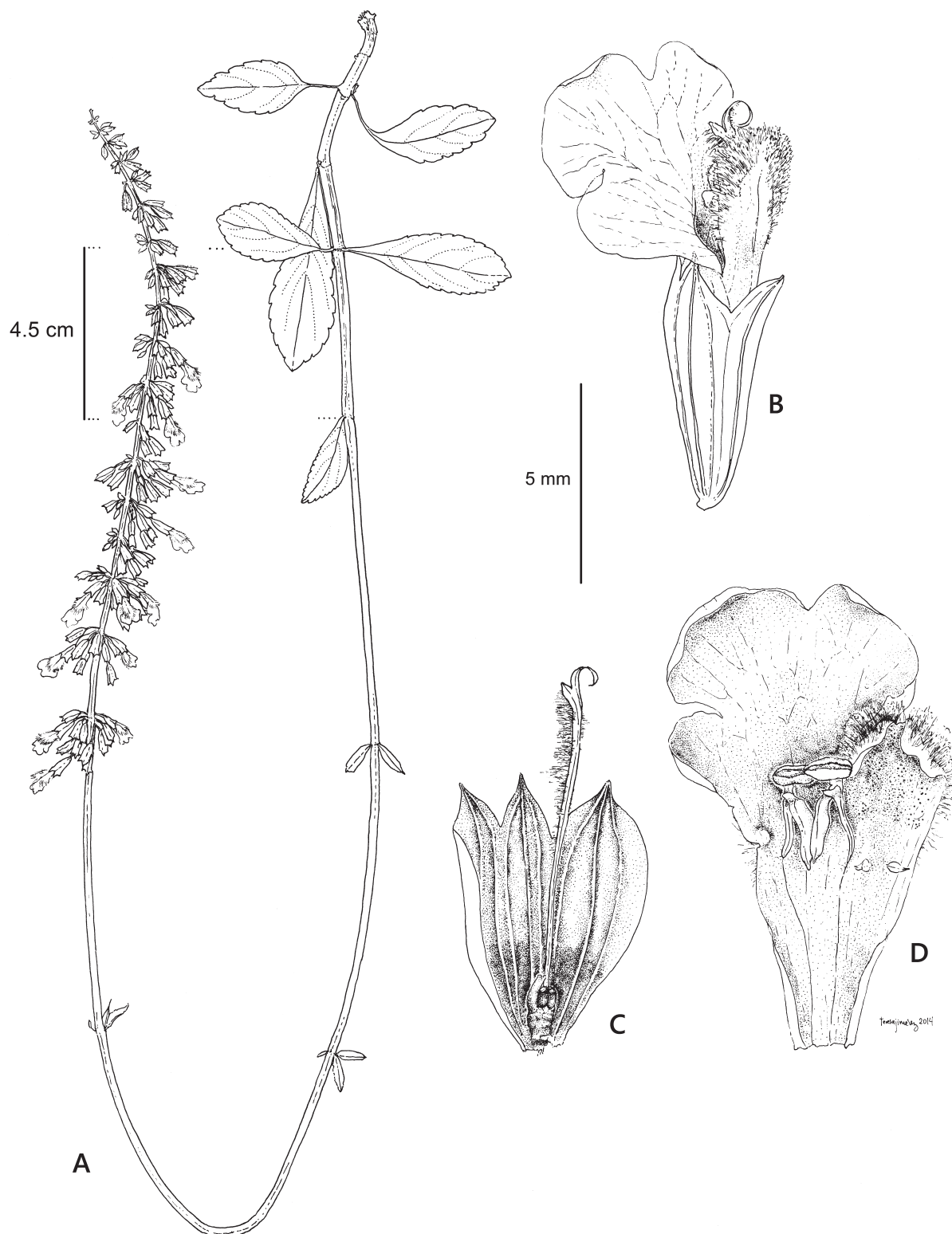


FIGURE 2. *Salvia semiscaposa*. A) Branch with inflorescence. Flower: B) Lateral view; C) Dissected calyx with style, gynobase and gland; D) Dissected corolla with gubernaculum and staminodes. Illustration drawn from the holotype (FCME) by Teresa Jiménez.

Additional specimens examined:—MEXICO, Estado de México: por la carretera a Cañadas de Nanchititla, cerca de 6 km al W, antes de la desviación al parque, 1765 m, 18° 52'46.3"N, 100°23'13.8"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 18* (FCME!); arroyo en la primera puerta del camino del Parque Ecológico Sierra de Nanchititla, que va hacia el mirador de la Cañada, 1665 m, 18°51'23.9"N, 100°25'30.3"W, 10 November

2011, *Fragoso-Martínez & Martínez-Gordillo 19* (FCME!); alrededores del mirador a la cascada del parque ecológico Sierra de Nanchititla, 1503 m, 18°49'21.8"N, 100°25'32.3"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 26* (FCME!); por la carretera que va de Cañadas de Nanchititla a Villa Luvianos, ca. 2 km al E de la desviación al parque, 1795 m, 18°52'10.5"N, 100°24'48.3"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 31* (FCME!); ca. 6.4 km al E de la desviación al Parque Sierra de Nanchititla, por la carretera a Villa Luvianos, 1779 m, 18°52'47.5"N, 100°23'5.8"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 32* (FCME!); ca. 19–20 km al E de la desviación al Parque Sierra de Nanchititla, por la carretera a Villa Luvianos, 1800 m, 18°52'55.779"N, 100°18'14.8428"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 52* (FCME!); 8 km del Salitre, 1900 m, 18°52'54.5"N, 100°18'52.1"W, 6 December 2012, *Fragoso-Martínez et al. 123* (FCME!); 3 km antes de llegar al Salitre desde Nanchititla, 1700 m, 18°53'17"N, 100°17'39"W, 6 December 2012, *Fragoso-Martínez et al. 127* (FCME!); Cerro de La Culebra, Luvianos, Progreso, 1300 m, 7 September 1954, *Matuda et al. 31507* (MEXU!); La Junta, Dto. Valle de Bravo, 650–900 m, 11 September 1954, *Matuda et al. 31640* (MEXU!); Cañada de Nanchititla, 1800 m, 4–12 December 1954, *Matuda s.n.* (MEXU!), *31980* (MEXU!); 52 km al SW de Nanchititla, 2000 m, January 1973, *Medrano et al. 5046* (MEXU!); Sierra de Nanchititla a lo largo de cañada, 1930 m, 20 January 1973, *Medrano et al. 5162* (MEXU!); 1.7 km antes de la entrada al parque estatal Sierra de Nanchititla, 1813 m, 18°52'16.9"N, 100°24'52.7"W, 21 November 2012, *Rojas et al. 2424* (FCME!); La Cascada, parque estatal Sierra de Nanchititla, 1490 m, 18°49'24.6"N, 100°25'31.8"W, 21 November 2012, *Rojas et al. 2480* (FCME!).

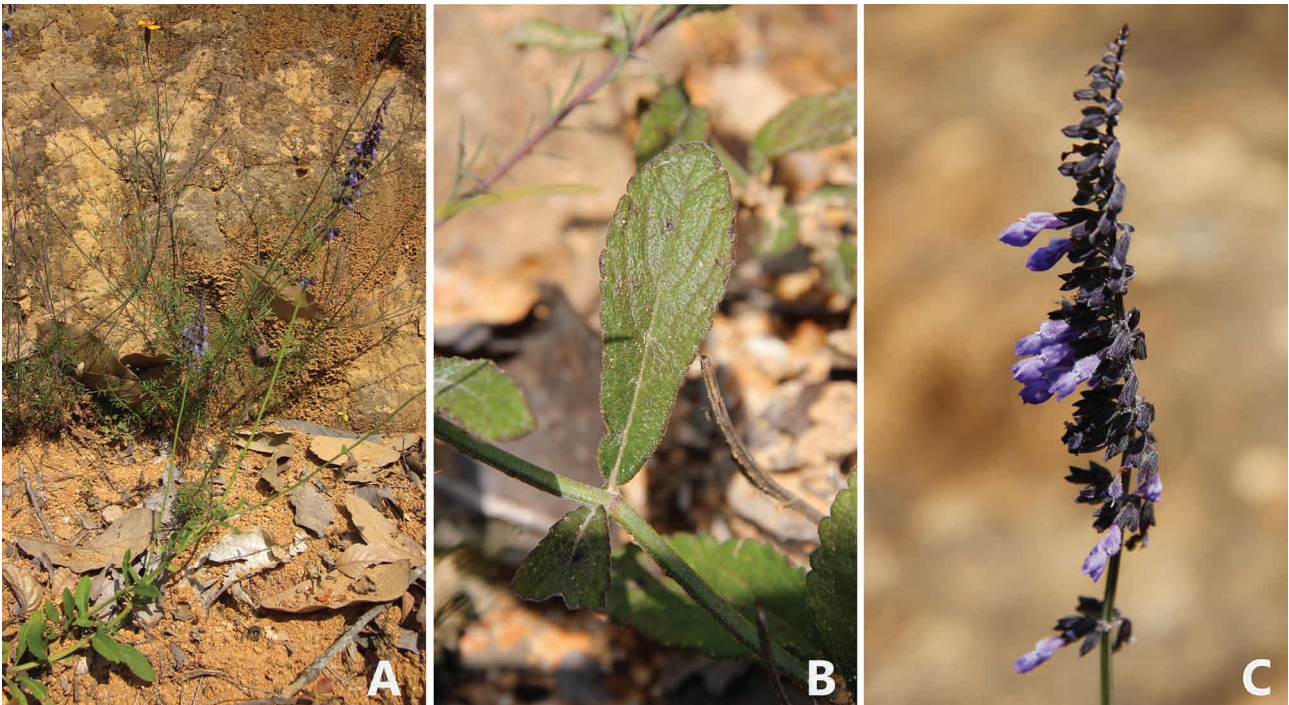


FIGURE 3. *Salvia semiscaposa*. A) Plant habit, B) Leaf blade detail, C) Inflorescence detail. (Photographs by I. Fragoso).

Discussion

The new species is a member of section *Lavanduloideae*. In a preliminary phylogeny of the section obtained from a parsimony analysis that combined morphological data (qualitative, quantitative and geometric morphometrics data) as well as two molecular markers (the nuclear ribosomal internal transcribed spacer or ITS and the plastid *trnL-trnF* intergenic spacer) (Fragoso-Martínez 2014), *S. semiscaposa* is sister to *S. rzedowskii*. These species share three substitutions on the ITS region, corolla and leaf proportions as synapomorphies. Morphologically, *S. rzedowskii* is different from *S. semiscaposa*; the main differences are the erect habit, the white corollas, and the strongly acute calyx lobes in *S. rzedowskii* (Table 1). Instead, *S. semiscaposa* has a decumbent habit (Fig. 3A), purple corollas (Fig. 3C) and obtuse-apiculate calyx lobes (Fig. 2C). Both species are the sister group to a clade which includes three scapose-like species: *S. scaposa*, *S. teresae* Fernald (1900: 506), and *S. heterofolia* Epling & Mathias (1957: 310).

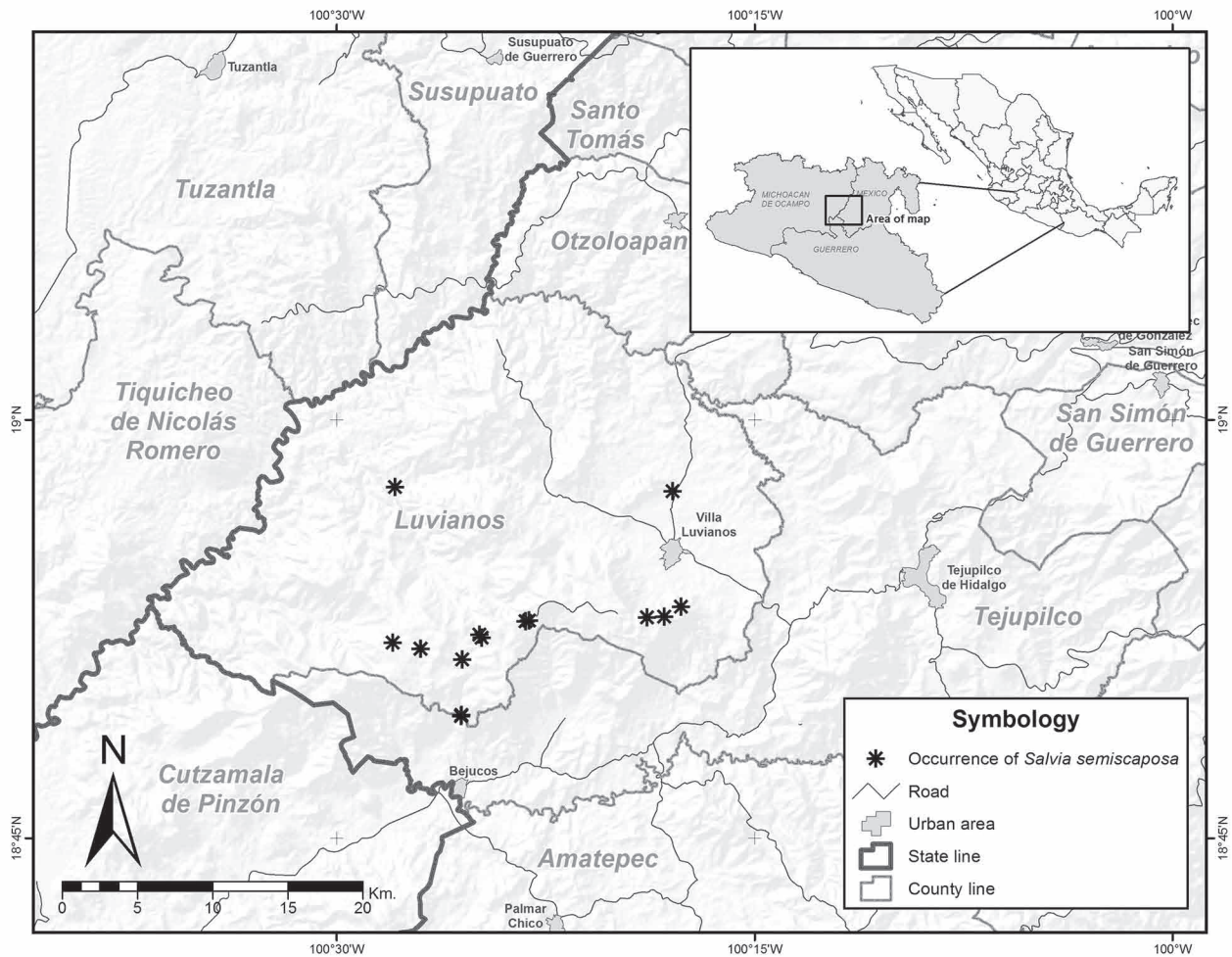


FIGURE 4. Distribution of *Salvia semiscaposa* in Mexico.

TABLE 1. Differences between *Salvia semiscaposa*, *S. rzedowskii*, *S. scaposa* and *S. helianthemifolia*.

	<i>S. semiscaposa</i>	<i>S. rzedowskii</i>	<i>S. scaposa</i>	<i>S. helianthemifolia</i>
Stem	long and decumbent	long and erect	short and erect	short and erect
Leaf and calyx indumentum	appressed-hirsute	appressed-hirsute	appressed-hirsute on the veins	appressed-hirsute on the veins
Leaf shape	obovate to ovate	elliptical	elliptical	ovate
Number of flowers per verticillaster	more than 6 flowers	more than 8 flowers	2–4(–6) flowers	6(–8)–10 flowers
Distance between verticillasters	0.5–2 cm	0.2–2 cm	0.5–4.5 cm	0.8–3.5 cm
Calyx position	divaricate to reflexed	usually divaricate	reflexed	reflexed
Posterior calyx lobes shape	narrow, apex apiculate	narrow, apex acute	broad, obtuse-mucronate	narrow, apex apiculate
Corolla color	lilac or purple	white	lilac	purple, occasionally white

Morphologically *Salvia semiscaposa* resembles *S. scaposa*. Both species share a similar habit and inflorescence morphology. Nevertheless, the stem in the latter species is short and erect, while it is usually longer and procumbent in the former (Fig. 3A). Some populations of *Salvia scaposa* have developed distal leaves (e.g. Taxco and Tetipac populations) but the typical form is similar to *S. semiscaposa* in having only the leaves at the base well developed (e.g. Sultepec and Zacualpan populations). Other differences between the two species are the indumentum on leaves and calyx; *S. scaposa* has both surfaces sparsely covered with short appressed trichomes whereas *S. semiscaposa* is moderately to densely covered with long appressed-hirsute trichomes (Table 1). Moreover, the leaf shape toward branch apex in *S. scaposa* is elliptical whereas *S. semiscaposa* has obovate leaves (Table 1, Figs. 3B and 6). Concerning

the inflorescences of both species, *S. semiscaposa* can be distinguished by the presence of more than six flowers per verticillaster, whereas there are only 2–4, occasionally 6 flowers in *S. scaposa*, with a greater distance between the verticillasters (Figs. 5A and 5B, Table 1). Lastly the posterior calyx lobes of *S. semiscaposa* are narrower than those of *S. scaposa*, and the tip is apiculate (Table 1).

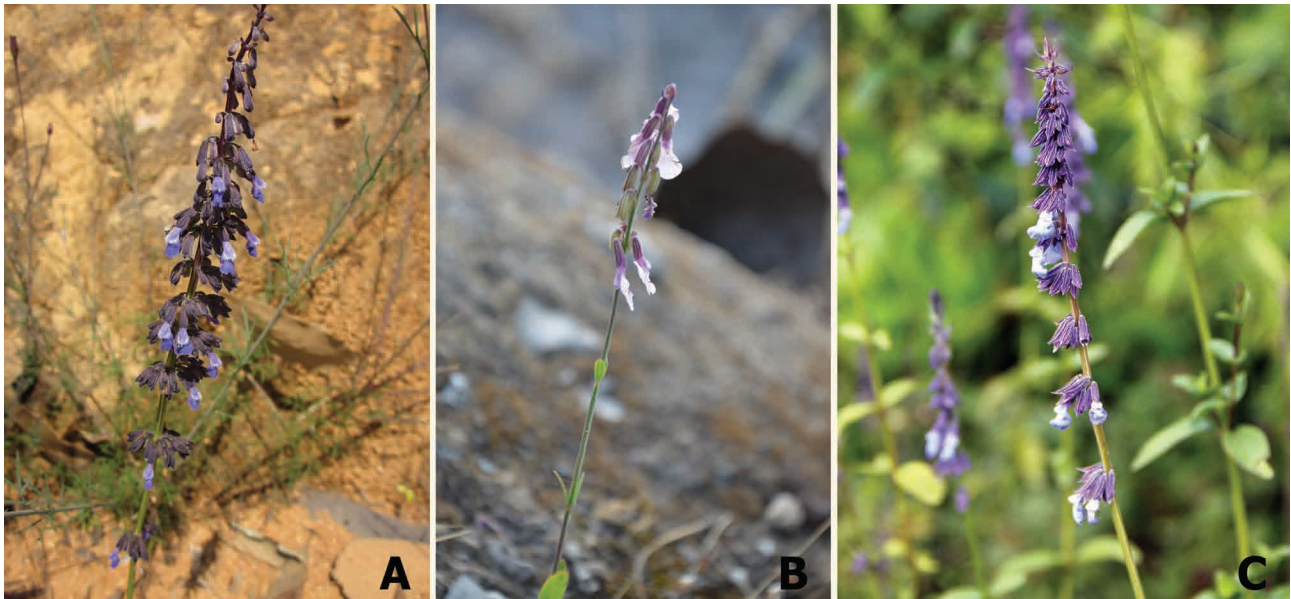


FIGURE 5. Inflorescence morphology of: A) *Salvia semiscaposa*; B) *S. scaposa* and C) *S. helianthemifolia*. (Photographs by I. Fragoso and E. Martínez).

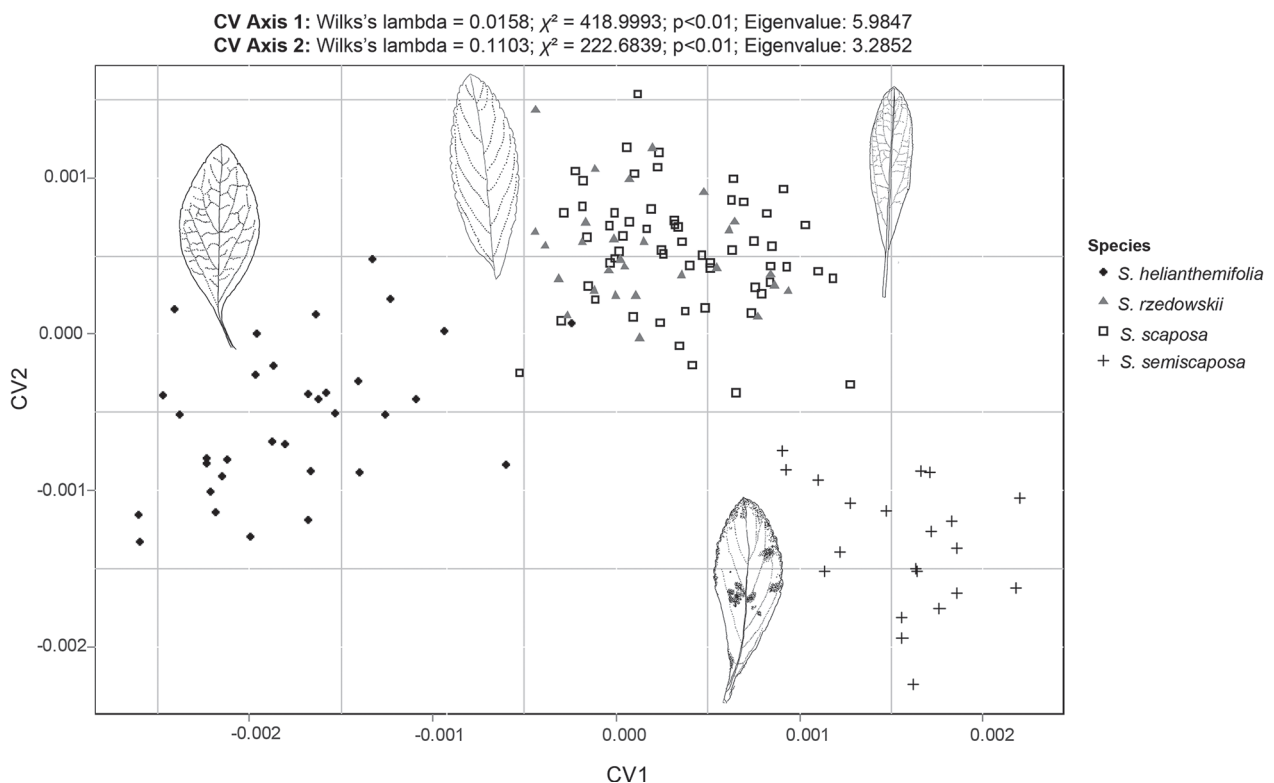


FIGURE 6. Scatterplot of canonical variates (CV), CV1 vs. CV2 from the geometric morphometric analysis of $n = 140$ leaf blade configurations of landmarks and semilandmarks. Illustrations of the structures (not in scale) for each species are shown for comparison purposes.

S. helianthemifolia is another species that resembles *S. semiscaposa* primarily in the inflorescence morphology. The main difference between these species is stem orientation, the former is an erect herb whereas *S. semiscaposa* is a

decumbent herb. Also the shape of the leaf blades differs significantly, being ovate in *S. helianthemifolia* and obovate in the new species (Table 1, Fig. 6). Regarding the inflorescence morphology, characters like the distance between verticillasters and calyx orientation overlap between both species (Figs. 5A and 5C); however, there is a tendency in *S. helianthemifolia* to have a greater length between verticillasters (up to 3.5 cm vs. 2 in *S. semiscaposa*, Table 1). Finally, the surface of the calyces of both species is appressed-hirsute, but in *S. helianthemifolia* the trichomes are only distributed on the veins.

The discriminant analyses of geometric morphometric data showed the leaf blade shapes are significantly different among three groups: *Salvia semiscaposa*, *S. helianthemifolia* and a group formed by two species with similar leaf blade shape: *S. scaposa* and *S. rzedowskii* (Fig. 6). The differences in shape between the latter group and the new species are chiefly in the middle of the leaf to the apex, where *S. semiscaposa* is broader and thus has an obovate leaf shape (Fig. 6) while in *S. scaposa* and *S. rzedowskii* the leaf blade is narrower and elliptical (Fig. 6). Conversely, in *S. helianthemifolia* the central portion of the leaf is broader than in *S. semiscaposa* resulting in an ovate shape (Fig. 6). In the group assignments tests from the CVA, none of the specimens of *S. semiscaposa* were misclassified; however a leaf blade from one specimen of *S. scaposa* was classified as similar to the new species (Table 2). Also most of the specimens of *S. helianthemifolia* (96.96%) were assigned correctly. On the other hand, the leaf blades of *S. rzedowskii* and *S. scaposa* have the same shape (elliptic-oblong) which causes the specimens represented by points in the scatterplot to overlap (Table 2, Fig. 6). This suggests leaf blade shape is a good identification marker of *S. semiscaposa* but only in a comparison with specimens of the other three species (Table 2, Fig. 6).

TABLE 2. Group assignment test based on Mahalanobis distances in the space of the significant canonical variates axes, the original groups are along rows and the CVA groups along columns.

	<i>S. semiscaposa</i>	<i>S. scaposa</i>	<i>S. rzedowskii</i>	<i>S. helianthemifolia</i>
<i>S. semiscaposa</i>	21	0	0	0
<i>S. scaposa</i>	1	31	26	0
<i>S. rzedowskii</i>	0	9	19	0
<i>S. helianthemifolia</i>	0	0	1	32

Key to the species of section *Lavanduloideae* from type locality of the new species

1. Pedicels tilted downwards, mature calyces reflexed2
1. Pedicels erect or spreading, mature calyces ascendant or divaricate5
2. Plants with erect stems *Salvia helianthemifolia*
2. Plants with procumbent stems or scapose habit3
3. Distal leaves evenly developed along the stems, leaves elliptical-lanceolate to linear; inflorescences spiciform
..... *Salvia heterofolia*
- Distal leaves scarcely developed on the stems, basal leaves obovate or ovate; inflorescences scapose 4
4. Herbs 0.4–1 m tall; leaf surfaces moderately to densely covered with long appressed-hirsute trichomes; verticillasters with more than 6 flowers each..... *Salvia semiscaposa*
- Herbs 0.2–0.4 m tall; leaf surfaces sparsely covered with short appressed trichomes; verticillasters with 2–6 flowers each.....
..... *Salvia scaposa*
5. Plants with exclusively white flowers; calyx lobes caudate, 2–5 mm long*Salvia rzedowskii*
- Plants with blue or purple flowers; calyx lobes acute to obtuse, 1–2.5 mm long6
6. Leaf blades ovate-elliptical, glabrate; compact inflorescences (central verticillasters no more than 3 mm apart); pedicels inconspicuous *Salvia stachyoides*
- Leaf blades oblong-elliptical or elliptic-lanceolate, hirsute to pubescent; lax or interrupted inflorescences (central verticillasters more than 0.5 mm apart); pedicels conspicuous 1–2.5 mm long7
7. Interrupted inflorescences, central verticillasters 1–3.5 cm apart; calyx surface lanate, calyx lobes acute..... *Salvia moniliformis*
- Lax inflorescences, central verticillasters 0.5–1.5 cm apart; calyx surface pubescent, calyx lobes obtuse, apex mucronate
..... *Salvia lavanduloides*

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References

- Bedolla-García, B.Y., Lara-Cabrera, S.I. & Zamudio, S. (2011) Dos nuevas especies de *Salvia* (Lamiaceae) del centro occidente de México. *Acta Botanica Mexicana* 95: 51–63.
- Benthams, G. (1832–1836) *Labiatarum genera et species*. Ridgeway, London, 783 pp.
- Benthams, G. (1848) Labiatae. In: De Candolle, A. (Ed.) *Prodromus systematis naturalis regni vegetabilis*. Treuttel and Würtz, Paris, pp. 28–603.
- Epling, C. (1939) A revision of *Salvia* subgenus *Calosphace*. *Feddes Repertorium Specierum Novarum Regni Vegetabilis* 110: 1–383.
- Epling, C. (1940) Supplementary notes on American Labiatae. *Bulletin of the Torrey Botanical Club* 67: 509–534.
<http://dx.doi.org/10.2307/2480972>
- Epling, C. (1941) Supplementary notes on American Labiatae-II. *Bulletin of the Torrey Botanical Club* 68: 552–568.
<http://dx.doi.org/10.2307/2481456>
- Epling, C. (1947) Supplementary notes on American Labiatae-IV. *Bulletin of the Torrey Botanical Club* 74: 512–518.
<http://dx.doi.org/10.2307/2481876>
- Epling, C. (1951) Supplementary Notes on American Labiatae-V. *Brittonia* 7: 129–142.
<http://dx.doi.org/10.2307/2804702>
- Epling, C. & Jativa, C. (1966) Supplementary Notes on American Labiatae-IX. *Brittonia* 18: 255–265.
<http://dx.doi.org/10.2307/2805366>
- Epling, C. & Mathias, M.E. (1957) Supplementary Notes on American Labiatae-VI. *Brittonia* 8: 297–313.
<http://dx.doi.org/10.2307/2804980>
- Espejo, A. & Ramamoorthy, T.P. (1993) Revisión taxonómica de *Salvia* sección *Sigmoideae* (Lamiaceae). *Acta Botanica Mexicana* 23: 65–102.
- Fernald, M.L. (1900) A synopsis of the Mexican and Central American species of *Salvia*. *Proceedings of the American Academy of Arts and Sciences* 35: 489–556.
<http://dx.doi.org/10.2307/25129966>
- Fragoso-Martínez, I. & Martínez-Gordillo, M. (2013) Una nueva especie del género *Salvia* sección *Membranaceae* de Guerrero, México. *Acta Botanica Mexicana* 103: 1–9.
- Fragoso-Martínez, I. (2014) *Análisis filogenético del complejo Salvia lavanduloides Kunth (Lamiaceae)*. Master's thesis, Universidad Nacional Autónoma de México, México, 134 pp.
- González-Gallegos, J.G. (2013) *Salvia albicalyx* and *Salvia topiensis* (Lamiaceae), two new species from Durango, Mexico. *Phytotaxa* 77 (1): 9–18.
<http://dx.doi.org/10.11646/phytotaxa.77.1.3>
- González-Gallegos, J.G. & Aguilar-Santelises, R. (2014) *Salvia tilantongensis* (Lamiaceae), una especie nueva de la Mixteca Alta de Oaxaca, México. *Acta Botanica Mexicana* 109: 1–22.
- González-Gallegos, J.G. & Castro-Castro, A. (2013) New insights on *Salvia platyphylla* (Lamiaceae) and description of *S. pugana* and *S. albiterrarum*, two new species from Jalisco, Mexico. *Phytotaxa* 93 (2): 47–60.
<http://dx.doi.org/10.11646/phytotaxa.93.2.1>
- González-Gallegos, J.G., Morales-Arias, J.G. & Rodríguez-Hernández, J.L. (2012a) *Salvia cacomensis* (Lamiaceae), a new species from Jalisco, Mexico. *Revista Mexicana de Biodiversidad* 83: 341–346.
<http://dx.doi.org/10.7550/rmb.26217>
- González-Gallegos, J.G., Vázquez-García, J.A. & Cházaro-Basáñez, M.J. (2013) *Salvia carreyesii*, *Salvia ibugana* and *Salvia ramirezii* (Lamiaceae), three new species from Jalisco, Mexico. *Revista Mexicana de Biodiversidad* 84: 7–19.
<http://dx.doi.org/10.7550/rmb.29131>
- González-Gallegos, J.G., Vázquez-García, J.A., Santana-Michel, F.J., Cuevas-Guzmán, R. & Guzmán-Hernández, L. (2012b) *Salvia meera*, *S. rogersiana*, *S. santanae* and *S. concolor* var. *iltisii* (Lamiaceae), three new species and a variety from Jalisco, Mexico. *Revista Mexicana de Biodiversidad* 83: 591–604.
<http://dx.doi.org/10.7550/rmb.26217>
- Iltis, H.H., González-Gallegos, J.G., Cochrane, T.S. & Vázquez-García, J.A. (2012) A new species and a new subspecies of *Salvia*

- (Lamiaceae) from Jalisco and Michoacán, Mexico. *Brittonia* 64: 343–352.
<http://dx.doi.org/10.1007/s12228-012-9237-1>
- Klitgaard, B. (2007) Three new species in *Salvia* subgenus *Calosphace* (Lamiaceae) from Mesoamerica. *Novon* 17: 206–211.
[http://dx.doi.org/10.3417/1055-3177\(2007\)17\[206:TNSISS\]2.0.CO;2](http://dx.doi.org/10.3417/1055-3177(2007)17[206:TNSISS]2.0.CO;2)
- Klitgaard, B. (2012) *Salvia* L. In: Davidse, G., Sousa S., M., Knapp, S. & Chiang, F. (Eds.) *Flora Mesoamericana 4 (2), Rubiaceae a Verbenaceae*. Missouri Botanical Press., St. Louis, pp. 396–424.
- Kunth, C.S. (1817) *Nova genera et species plantarum II*. The Greek-Latin-Germanic Library, Paris, 405 pp.
- Lara-Cabrera, S.I., Bedolla-García, B.Y. & Zamudio, S. (2013) *Salvia tonaticensis* (Lamiaceae), a rare new species from Mexico. *Brittonia* 66: 1–7.
<http://dx.doi.org/10.1007/s12228-012-9297-2>
- Linnaeus, C. (1753) *Species Plantarum*. Salvius, Stockholm, 1200 pp.
- Martínez-Gordillo, M. & Lozada-Pérez, L. (2011) Una nueva especie de *Salvia* (Lamiaceae) de Guerrero, México. *Brittonia* 63: 211–214.
- Martínez-Gordillo, M., Fragoso-Martínez, I., García-Peña, M.R. & Montiel, O. (2013) Géneros de Lamiaceae de México, diversidad y endemismo. *Revista Mexicana de Biodiversidad* 84: 30–86.
<http://dx.doi.org/10.7550/rmb.30158>
- Meyer, D., Dimitriadou, E., Hornik, K., Weingessel, A., Leisch, F., Chang, C. & Lin, C. (2014) Misc Functions of the Department of Statistics (e1071), version 1.6-4. Available from: <http://cran.r-project.org/web/packages/e1071/> (accessed 6 December 2014)
- R Core Team (2014) *R: A language and environment for statistical computing*. R foundation for Statistical Computing, Vienna. Available from: <http://www.R-project.org/> (accessed 25 August 2014)
- Ramamoorthy, T.P. (1984a) Typifications in *Salvia* (Lamiaceae). *Taxon* 33: 322–324.
<http://dx.doi.org/10.2307/1221181>
- Ramamoorthy, T.P. (1984b) Notes on *Salvia* (Labiatae) in Mexico, with three new species. *Journal of the Arnold Arboretum* 65: 135–143.
- Ramamoorthy, T.P. & Elliot, M. (1998) Lamiaceae de México: diversidad, distribución, endemismo y evolución. In: Ramamoorthy, T.P., Bye, R., Lot, A. & Fa, J. (Eds.) *Diversidad biológica de México: orígenes y distribución*. Instituto de Biología, Universidad Nacional Autónoma de México, Distrito Federal, pp. 129–145.
- Rohlf, J.F. (2010) *tpsDig*. Version 2.16. Department of Ecology and Evolution, State University of New York at Stony Brook, New York, EUA.
- Santos, E. (1995) Estudo das inflorescências no gênero *Salvia* L. subgênero *Calosphace* (Benth.) Benth. (Lamiaceae). *Bradea* 6: 372–380.
- Sheets, H.D. (2004a) *SemiLand6 Manual*. Canisius College, New York. Available from: <http://www3.canisius.edu/~sheets/morphsoft.html> (accessed 27 February 2012)
- Sheets, H.D. (2004b) IMP: *Integrated Morphometrics Package*. Canisius College, New York. Available from: <http://www3.canisius.edu/~sheets/morphsoft.html> (accessed 27 February 2012)
- Turner, B.L. (2008) Recension of *Salvia* sect. *Farinaceae*. *Phytologia* 90: 163–175.
- Turner, B.L. (2013) Taxonomic overview of the Mexican species of *Salvia* sect. *Flocculosae* (Lamiaceae). *Phytoneuron* 36: 1–11.
- Villaseñor, J.L. (2004) Los géneros de plantas vasculares de la flora de México. *Boletín de la Sociedad Botánica de México* 75: 105–135.
- Walker, J.B., Sytsma, K.J., Treutlein, J. & Wink, M. (2004) *Salvia* (Lamiaceae) is not monophyletic: implications for the systematics, radiation, and ecological specializations of *Salvia* and tribe Mentheae. *American Journal of Botany* 91: 1115–1125.
<http://dx.doi.org/10.3732/ajb.91.7.1115>
- Wickham, H. (2009) *ggplot2: elegant graphics for data analysis*. Springer. New York. Available from: <http://ggplot2.org/> (accessed 6 December 2014)
- Zarucchi, J.L. (1993) Lamiaceae. In: Brako, L. & Zarucchi, J.L. (Eds.) *Catálogo de las Angiospermas y Gimnospermas del Perú. Monographs in Systematic Botany from the Missouri Botanical Garden* 45: 579–590.

Appendix. Specimens photographed for geometric morphometric analyses

Salvia helianthemifolia:—MEXICO, Guanajuato. Cerro Zamorano, parte alta, 2800 m, 24 October 1988, *Rzedowski 47803* (MEXU!). Hidalgo. “El Cirio”, aproximadamente 1.2 km al W de San Nicolás, 1680 m, 20°19'19"N, 98°12'6"W, 5 September 1993, *Luna et al. 1469* (FCME!); Cerro de las Ventanas, 7 km al N de Pachuca, 2900 m, 25 December 1973, *Rzedowski 31572* (FCME!). Estado de México. Cerro del Huilote, Parque Nacional Lagunas de Zempoala, 2590 m, 14 January 1984, *Aguilar ZC-43* (FCME!); rumbo al llano de Los Tres Gobernadores, por San Juan Xoconusco, 2740 m, 19°22'30"N, 100°14'46"W, 20 March 2005, *Cornejo et al. 1029* (FCME!); parque Nevado de Toluca, 5 km al E de Mesón Viejo, por la carretera Toluca-Altamirano, rumbo a Toluca, 3003 m, 19°10'31.88"N, 99°51'34.16"W, 11 November 2011, *Fragoso-Martínez 100* (FCME!); aprox. 14 km rumbo a Oxtotilpan carr. Toluca-Oxtotilpan, 3176 m, 19°11'3.09"N, 99°51'21.8"W, 21 November 2012, *Fragoso-Martínez 110* (FCME!); cruceo-Agua Blanca, 13 January

1936, *Hinton 8828* (MEXU!); Cerro Pelón camino a la colonia, 2620 m, 19°22'10"N, 100°15'54"W, 13 November 2005, *Salinas et al. 938* (FCME!); parque Nevado de Toluca, Ejido El Varal, 3090 m, 19°3'57"N, 99°56'27"W, 21 March 1996, *Villers 11* (MEXU!). Michoacán. Cerro Prieto, aprox. a 5 km al SE de Huajúmbaro, 2760 m, 17 September 1985, *Almazán et al. 582* (FCME!); Llano Largo, aprox. a 1.5 km al NE de Los Azufres, 2940 m, 19 March 1986, *Almazán et al. 641* (FCME!); Cañada de San Pedro, aprox. a 3 km al NW de San Pedro Jácuaró, 2300 m, 6 January 1986, *Almazán et al. 879* (FCME!); Laguna Larga, Los Azufres, 2800 m, 6 December 1986, *Zamudio 5087* (FCME!).

Salvia rzedowskii:—MEXICO, Estado de México. km 6 carr. Zacualpan-Mamatla, 2000 m, 18°41'36.6"N, 99°47'53.6"W, 20 November 1981, *Castilla & Tejero 1539* (MEXU!); Nanchititla 3 km del Salitre, 5 October 1986, *Esquivel & Galicia s.n.* (MEXU!); 5 km de la Goleta hacia Sultepec, 2234 m, 18°41'44"N, 100°5'5.2"W, 22 November 2012, *Fragoso-Martínez 119* (FCME!); camino a Sultepec, 3 km antes de San José del Potrero, 2265 m, 18°44'56.6"N, 100°1'54.9"W, 22 November 2012, *Fragoso-Martínez 121* (FCME!); 6 km de la Goleta hacia Sultepec, 2175 m, 18°41'50.3"N, 100°4'57.5"W, 7 December 2012, *Fragoso-Martínez 129* (FCME!); cerro entre Sultepec y Amatepec, 2200 m, 31 December 1953, *Matuda et al. 30092* (MEXU!); La Corona, Zacualpan, 1 February 1954, *Matuda et al. 30333*, 7–8 December 1963, *Matuda et al. s.n.* (MEXU!); en barranca, cerca de Amatepec, 1500 m, 29 December 1953, *Matuda et al. 30036* (MEXU!); Cerro del Loro, cerca de Sultepec, 29 December 1962, *Paray 3348* (MEXU!); rumbo a Zacualpan, 2327 m, 18°39'39.4"N, 99°46'52.7"W, 18 October 2012, *Rojas et al. 1930, 1990* (FCME!); 1 km de las Peñas, 2186 m, 18°44'55.5"N, 100°0'6.1"W, 19 October 2012, *Rojas et al. 2003, 2038* (FCME!); La Ciénega, 3 km al S de Sultepec, 2350 m, 10 March 1973, *Rzedowski 30326* (MEXU!).

Salvia semiscaposa:—MEXICO, Estado de México. Por la carretera a Cañadas de Nanchititla, cerca de 6 km al W, antes de la desviación al parque, 1765 m, 18°52'46.3"N, 100°23'13.8"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 17, 18* (FCME!); alrededores del mirador a la cascada del parque ecológico Sierra de Nanchititla, 1503 m, 18°49'21.8"N, 100°25'32.3"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 26* (FCME!); arroyo en la primera puerta del camino del Parque Ecológico Sierra de Nanchititla, que va hacia el mirador de la Cañada, 1665 m, 18°51'23.9"N, 100°25'30.3"W, 10 November 2011, *Fragoso-Martínez & Martínez-Gordillo 19* (FCME!); ca. 19–20 km al E de la desviación al Parque Sierra de Nanchititla, por la carretera a Villa Luvianos, 1800 m, 18°52'55.7"N, 100°18'14.8"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 52* (FCME!); ca. 6.4 km al E de la desviación al Parque Sierra de Nanchititla, por la carretera a Villa Luvianos, 1779 m, 18°52'47.5"N, 100°23'5.8"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 32* (FCME!); por la carretera que va de Cañadas de Nanchititla a Villa Luvianos, ca. de 2 km al E de la desviación al parque, 1795 m, 18°52'10.5"N, 100°24'48.3"W, 11 November 2011, *Fragoso-Martínez & Martínez-Gordillo 31* (FCME!); Cañada de Nanchititla, 1800 m, 4–12 December 1954, *Matuda s.n.* (MEXU!), *31980* (MEXU!); La Junta, Dto. Valle de Bravo, 650–900 m, 11 September 1954, *Matuda et al. 31640* (MEXU!).

Salvia scaposa:—MEXICO, Guerrero. Cerro Huizteco, 2200 m, 19 September 2008, *Cano 1842* (FCME!); 16.5 km al NW de Taxco, camino a Tetipac, 2280 m, 25 January 1986, *Castelo 513* (FCME!); camino templo al Viento, parque Cerro El Huizteco, 2340 m, 6 September 1985, *Castillo et al. 138* (FCME!); 2 km al SW de la entrada al Parque Cerro El Huizteco, 2380 m, 18°35'56"N, 99°36'33"W, 7 September 1985, *Castillo et al. 175* (FCME!); cerca de la cañada El Limón, Campo Morado, 1248 m, 18°11'52.25"N, 100°9'50"W, 17 July 2006, *Cruz-Durán et al. 6288* (FCME!); filo de Cerro Tepehuaje, Campo Morado, 1393 m, 18°12'35.928"N, 100°9'0'23.57"W, 19 July 2006, *Cruz-Durán et al. 6420* (FCME!); Cerro del Huizteco, cerca del monumento al Viento, 2500 m, 12 October 1996, *Domínguez-Licona 71* (FCME!); a 7 km de Taxco, rumbo a Tetipac, 1980 m, 30 September 1984, *Fonseca 860* (FCME!); Camino templo al Viento, parque Cerro El Huizteco, 2340 m 6 September 1985, *González et al. 121* (FCME!); a 7 km de Tetipac, rumbo a Taxco de Alarcón, 1940 m, 10 December 1996, *Domínguez-Licona 170* (FCME!); 14 km al NE de Taxco, rumbo a Tetipac, 18°35'47.2"N, 99°37'13.3"W, 25 January 1986, *López 169* (FCME!); aproximadamente 2.5 km al NO de Taxco, camino a Casahuates-Tetipac, 2120 m, 31 October 1984, *Lorea 3310* (FCME!); El Huizteco, 2400 m, 19 November 1998, *Macedonio 448* (FCME!); Parque el Huizteco, 2367 m, 18°36'21.4"N, 99°36'21.4"W, 29 September 2010, *Martínez 5540* (FCME!); 29 September 2010, *Martínez 5681* (FCME!); Coxcatlán, 1877 m, 18°30'10"N, 99°28'2.2"W, 30 September 2011, *Morales 486* (FCME!); Cerro Huizteco, 2250 m, 2 October 1995, *Ortega 1* (FCME!); Agua de Obispo, *Palma 249* (FCME!); camino templo al Viento, 1 km de la entrada parque Cerro El Huizteco, 2320 m, 6 September 1985, *Rendón 110* (FCME!); El Huizteco, 2400 m, 19 November 1998, *Reyna 527* (FCME!); Casahuates, aproximadamente a 2 km de la entrada, 2350 m, 14 November 1987, *Terán & Matías 256* (FCME!). Estado de México. 5 km de la Goleta hacia Sultepec, 2234 m, 18°41'44"N, 100°5'5.2"W, 22 November 2012, *Fragoso-Martínez et al. 120* (FCME!); camino a Puerto Oscuro, 2383 m, 18°34'8.56"N, 99°40'7.3"W, 24 September 2012, *Rojas et al. 1472* (FCME!), *1476* (FCME!); 1 km a las Peñas, 2186 m, 18°44'55.5"N, 99°10'6.1"W, 19 October 2012, *Rojas et al. 1994* (FCME!).