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Systematics of the genus *BDALLOPHYTUM* (CYTINACEAE)

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ABSTRACT

The genus *Bdallophytum* is comprised of root parasitic plants distributed in northern neotropics. In Mexico occur all the species of the genus, two of which are endemic. The genus has previously been positioned within the tribe Cytineae of the Rafflesiaceae, but based on results from molecular phylogenetic analyses, this tribe is currently recognized at the rank of family as Cytinaceae. Historically, one to four species have been accepted in the genus, and the most-recent taxonomic treatment for the genus was realized more than 70 years ago. In the present work, a principal coordinate analysis was conducted in order to evaluate the identity and number of species in this genus. The results of this analysis suggest the recognition of three species. A taxonomic study with a key to species is presented, along with bibliographic information, morphological descriptions, specimens examined, ecological information, distributional maps and photos of the species.

Keywords: *Bdallophytum,* Cytinaceae, Mexico, neotropics, parasitic plants.

RESUMEN

El género *Bdallophytum* está integrado por plantas parásitas de raíces y restringe su distribución a la parte septentrional del neotrópico. En México se presentan todas sus especies, dos de las cuales son endémicas. Anteriormente se le ubicaba en la tribu Cytineae de la familia Rafflesiaceae, pero según los estudios filogenéticos basados en datos moleculares, este grupo se reconoce ahora a nivel de familia como Cytinaceae. En su historia se han reconocido para *Bdallophytum* de uno a cuatro componentes y la última revisión taxonómica para el género fue realizada hace más de 70 años. El presente trabajo se apoya en un análisis de coordenadas principales para evaluar la identidad y número de miembros que lo integran, reconociéndose tres especies. Se proporciona una clave de su identificación, así como datos bibliográficos, descripciones morfológicas, enumeración de los ejemplares estudiados, información ecológica, mapas de distribución y fotografías. Palabras clave: *Bdallophytum*, Cytinaceae, México, neotrópico, plantas parásitas.

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INTRODUCTION

The genus *Bdallophytum* Eichler comprises root parasitic plants, mainly on *Bursera* Jacq. ex L. (Burseraceae), its distribution restricted to the northern neotropics (Kuijt, 1969; Gomez, 1983). According to phylogenetic analyzes based on molecular data (Blarer et al., 2000; Nickrent et al., 2004), it belongs to the family Cytinaceae, a taxon segregated from Rafflesiaceae. The genus has been addressed in different floristic works, even as part of the family Rafflesiaceae, in which it is seen as consisting of one to four species (Harms, 1935; Gomez, 1983; Kuijt, 2001; Carranza-Gonzales, 2002). Although knowledge of the group in general is scarce, it is reported in some articles that have investigated various aspects of the biology of a species (García-Franco, 1996; Garcia-Franco and Rico-Gray, 1997a, b; Garcia-Franco et al., 1998), which have given us important information about these plants. The latest taxonomic work that looked at all components of *Bdallophytum* was performed over 70 years ago (Harms, 1935). Moreover, the genus is under-represented in herbaria and, coupled with this, many of the specimens are not in good condition, which has raised doubts about the validity of some of the proposed names. Under this scenario it became necessary to evaluate the systematics of the group and apply phenetic analysis that would explore the identity and number of corresponding species.

METHODS

We conducted a literature search related to the genus *Bdallophytum* and related taxa including taxonomic, morphological, ecological and phylogenetic: Solms-Laubach, 1901; Harms, 1935; Kuijt, 1969, 2001; Gentry, 1973; Gomez, 1983; Bouman and Meijer, 1986, 1994, Garcia-Franco, 1996; Garcia-Franco and Rico-Gray, 1997a, b; Meijer, 1997; Garcia-Franco et al., 1998, Stevens, 2001; Carranza-Gonzales, 2002; Barkman et al., 2004; Nickrent et al., 2004; Burgoyne, 2006; Davis et al., 2007; Nickrent, 2007. We reviewed specimens from the following herbaria: ENCB, FCME, G, HUMO, K, MEXU, XAL and ZEA. The information was complemented with some exploration of virtual databases (Harvard University Herbarium (HUH), New York Botanical Garden (NY), Missouri Botanical Garden's Tropicos (MO) and United States National Herbarium (U.S.) and other electronic resources such as The Parasitic Plant Connection and the Angiosperm Phylogeny Website.

To develop a phenetic analysis, we created a data matrix with a total of 23 morphological characters (Table 1). The information was obtained from 31 specimens in good condition to evaluate their characteristics, which are marked with an asterisk (*) in the section of the taxonomic study specimens examined. Also the information of the type specimens of each species (either from protologue and/or directly from the specimen) was integrated. The basic data matrix was standardized using the average of the standard deviation and subjected to a principal coordinates analysis (PCA) using the program NTSYSpc 2.11T (Rohlf, 2004). The results were plotted in two dimensions and from this the taxonomic definition of species was recognized in this way, accompanied by descriptions, identification keys, distribution maps and figures for each.

The selected morphological characters (see Table 1) for phenetic analysis are described below:

Habit and vegetative structures. *Bdallophytum* species are parasitic plants without chlorophyll

(holoparasites) staying within the roots of their hosts. These plants have changed their vegetative structure into a complex cellular system called the endophyte (Kuijt, 1969), which occurs in all root tissues, mainly in the host phloem and secondary xylem (Garcia-Franco, 1996). At flowering, the endophyte system modifies host tissue structure, allowing it to have a constant supply of nutrients in the development of the flower structure, which emerges from shallow roots (García-Franco, 1996).

Inflorescences. They are spiciform, with a well-developed floral axis (Character 1, 2, 3), fleshy and covered with glandular trichomes, which can give a yellowish-brown color. The inflorescences has scales (characteristic 4, 5) in a rosette at the base of the axis and alternately arranged along the same. The scales have serrated margin or entire, with a coloration to almost black purple and covered by glandular pubescence. The number of flowers per inflorescence (character 6) may vary according to the species and is a useful character for recognition thereof.

Table 1. List of the characters and states used in the phenetic analysis.

Number	Character
1	inflorescence total length (cm)
2	major axis length (cm)
3	main axis thickness (mm)
4	scale length (mm)
5	scale width (mm)
6	number of flowers per inflorescence
7	types of flowers (1 - unisexual, 2 - hermaphrodites)
8	bract length (mm)
9	bract width (mm)
10	perianth length (mm)
11	basal diameter of perianth (mm)
12	perianth color (1 - cherry 2 - purple)
13	arrangement of the anthers (1 - ring, 2-irregular)
14	number of anthers
15	filament length (mm)
16	anthers with appendices (1 - yes, 2 - no)
17	anther length (mm)
18	style length (mm)
19	number of placentas
20	concrescent fruits (1 - yes, 2 - no)
21	fruit length (mm)
22	fruit width (mm)
23	seed length (mm)

Flowers. Are epigynous, unisexual or hermaphrodite (character 7), arranged helically on the shoot axis, always bracteate (character 8, 9). They have a foul odor (Meijer, 1997; *Steinmann 3080* (MEXU)), which together with the flower color attracts flies of the genus *Oxysarcodexia*, *Peckia* and *Perckiamya* (García-Franco and Rico-Gray, 1997a, b). The perianth is not

differentiated in calyx and corolla (character 10, 11) and the number of segments is (4 -) 8 to 11, is irregular in length and shape and imbricate. The perianth is campanulate and is externally covered with glandular pubescence. The color varies from cherry to purple (character 12).

Androecium. Is a taxonomically important structure, allowing for quick identification of species. The stamens are monadelphous, the filaments form and maintain a column (character 15) which at its apical portion is thickened, and the anthers are arranged annularly or irregularly (character 13). The anthers are oblong in all species but may be slightly curved or straight, are white in contrast to the perianth, this feature seems to play an important role in attracting pollinators. The anthers may have a projection of a yellowish connective (character 16), possibly also related to pollination, as in other families, for example, some members Apocynaceae have a connective projection (Endress, 1996).

Gynoecium. The ovary is unilocular with seven or more intrusive placentas (character 19), carrying a large number of ovules, these are orthotropic as in its sister group *Cytinus* and unitegmic (Bouman and Meijer, 1994). The individuality of the ovary may be very evident, as in *Bdallophytum americanum,* but in the other species of the large number of closely adjacent gynoecia does not allow a clear separation thereof. The style is very short (18 character) with a very noticeable capitate stigma, lobed and whitish to yellowish, it could function as an attractor for pollinators.

Fruit. It is a globose berry (character 21, 22) densely covered with glandular trichomes. The berries in some cases are agglomerated so that they form a kind of concrescent fruit (character 20).

Seeds. Numerous per fruit and very small (character 23), covered in mucilage. The shape is globose with an ornate surface, no raphe and hylum and the micropyle is on opposite side (Bouman and Meijer, 1994). The seeds do not show major differences that would allow separation of the species. Recorded disperser organisms are the rodent *Peromyscus mexicanus mexicanus* Saussure and ants of the genus *Atta* (García-Franco and Rico-Gray, 1997a, b). In the seed bank the germplasm of the parasite requires host chemical stimulants for germination (Garcia-Franco and Rico-Gray, 1997a).

TAXONOMIC HISTORY

The first species of *Bdallophytum* was released under the name of *Cytinus americanus* R. Br (Brown, 1844), representing the initial registration in America of a genus of holoparasite hitherto known from the Old World. Subsequently Liebmann described *Scytanthus* Liebm. with one species, *S. bambusarum* Liebm., but it was not related to the genus *Cytinus* L. However, *Scytanthus* was not accepted as a valid name because it was considered a variant spelling of an older name, *Skytanthus* Meyen, taxon belonging to the family Apocynaceae (Harms, 1935). Years later, Eichler (1872) proposed for the family Balanophoraceae the genus *Bdallophytum* with two species (*B. Andrieuxii* Eichler and *B. ceratantherum* Eichler), regardless of the other previously described species. By the late nineteenth century the taxa described above were integrated into a single genus, for which the names *Bdallophytum* (or its variant spelling *Bdallophyton*), *Cytinus* L., *Hypocistis* Adans., and *Scytanthus* Liebm. were applied

interchangeably (Hooker, 1873; Hemsley, 1882; Kuntze, 1891; Solms-Laubach, 1889). It is only now in the twentieth century that all American species in question were circumscribed within *Bdallophytum* (Solms-Laubach, 1901; Harms, 1935). This genus and the other members of *Cytinus* were within the family Rafflesiaceae as Tribe Cytineae (Solms-Laubach, 1889; Harms, 1935). Since then, the group's position as a tribe has long been maintained, although some authors already anticipated its elevation to the family level (Hutchinson, 1959; Takhtajan, 1997).

The use of molecular markers of the nucleus and mitochondria in phylogenetic analyses have shown that the conception of the family Rafflesiaceae in the traditional sense, composed of three or four tribes (Kuijt, 1969; Cronquist, 1981; Bouman and Meijer, 1986), is an artificial proposal based on convergent characters such as endoparasitism, reduced vegetative structures, and endogenous flowers and reproductive structures. Phylogenetic evidence revealed that the circumscribed tribes of Rafflesiaceae have affinities with assemblages located in different orders and these have been elevated to the level of family. The work of Nickrent et al. (2004) provided the first comprehensive overview of the relationships of this group of parasites and showed that family Cytinaceae, formerly tribe Cytineae, are related to taxa in the order Malvales, which are potentially linked with another group also segregated Rafflesiaceae (Apodanthaceae family), but the connections between the two groups and the relative position of these are not yet resolved (Nickrent et al., 2004). The recently obtained evidence puts Cytinaceae as sister to the family Muntingiaceae, which along with members of Thymelaeaceae form a group in the order Malvales *s.l.* (Nickrent, 2007). The remaining genera of Rafflesiaceae (*Rafflesia* R. Br., *Rhizanthes* Dumort. and *Sapria* Griff.) are more related to members of the order Malpighiales (Barkman et al., 2004, Davis et al., 2007). In this paper we consider that there are sufficient morphological and molecular reasons for recognizing *Bdallophytum* and *Cytinus* as components of a different family.

RESULTS

Numerical Analysis

The principal coordinates analysis (PCA) made for *Bdallophytum* species indicated that the first two components explain 83.6% of the variation. In Figure 1 one can recognize three groups that are delimited by ellipses. The first axis separates two and the second complementary axis allows recognition of the third set that one can consider as distinct species. The most important differential characters were the number of flowers (6), the type of flowers (7), the length of the perianth (10), the color of the perianth (12), the arrangement of the anthers (13) and the presence of anther appendages (16).

Type specimens for *Liebmann 1898 (B. bambusarum), Barclay sn (B. americanum)* and *Ervendberg 101 (B. ceratantherum)* were grouped into one of the clusters. The specimen of *Andrieux 50 (B. andrieuxii)* and *Pringle 4373 (B. oxylepis)* are included in different sets. The resulting pattern allows recognition of three species, which are addressed below.

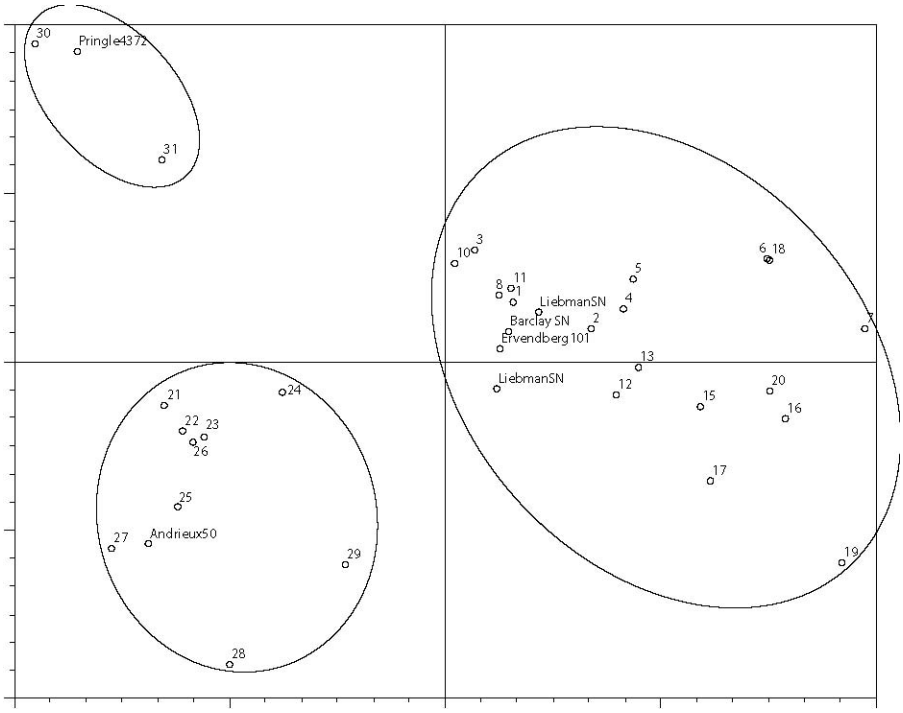

Fig 1. Graph from the principal coordinate analysis in which three groups have been delimited with ellipses, which are interpreted as distinct species. The names in each set correspond to the type specimens of the species recognized for *Bdallophytum: B. americanum* (*s.n. Barclay.*)*, B. andrieuxii* (*Andrieux 50*)*, B. bambusarum* (*Liebmann sn.*)*, B. cerantatherum* (*Ervendberg 101*)*, B. oxylepis* (*Pringle 4373*)*.*

Taxonomy

Although there are studies that treat tribes as four separate entities Rafflesiaceae (Stevens, 2001; Burgoyne, 2006; Nickrent, 2007), this contribution is considered desirable to provide a description of the family Cytinaceae with taxa discussed here.

Cytinaceae (Brongn.) A. Rich. in Bory, Dict. Class. Hist. Nat 5: 301. 1824. Cytineae (Brongn.) Spach, Hist. Nat Veg. 10: 551. 1841 (Eucytineae). Cytinoideae Link, Handbuch 1: 368. *1829.* TYPE: L. *Cytinus* (1764).

Holoparasitic plants, dioecious, rarely monoecious or polygamo-monoecious, achlorophyllous. Vegetative tissue transformed into an embedded endophytic system within the host. Foliar scales form a rosette at the base and overlap along the simple floral axis. Inflorescences in cymes, racemes or spikes, but towards the apex with an umbelliform pattern, or rarely flowers solitary, bracteate. Flowers usually unisexual, when hermaphrodites the anthers are opposite the stigma, bracteate actinomorphic; perianth tubular or campanulate, pink, red, burgundy, purple, yellow or white; male flowers with perianth 4-9-lobed, imbricate, nectary present as small papillae at the base of perianth, filaments monadelphous, forming a column, anthers (2 -) 5-14 (-18), sometimes with a staminal appendage, extrorse, dehiscence longitudinal; female flowers with a perianth smaller than in the male, ovary 1-locular, inferior or semi-inferior, ovules numerous, placentas 8-

14, parietal intrusive, nectary present as in the male, style columnar, stigma capitate, lobed, viscous. Fruit a berry, sometimes with irregular dehiscence, pulp mucilaginous, translucent, seeds numerous, very small, globose. Number chromosomal $n = 12$ and 16.

Diversity and distribution. A family of two genera, *Cytinus* (8 spp.) recorded in Europe and Africa and *Bdallophytum* (3 spp.) present in Mexico and Central America.

Comment. The close relationship between *Bdallophytum* and *Cytinus* was recognized since the nineteenth century (Brown, 1844; Solms-Laubach, 1889); this assumption has not changed since then and brotherhood between these taxa has been corroborated with morphological and molecular data (Kuijt , 1969; Takhtajan, 1997; Bouman and Meijer, 1994; Nickrent et al., 2004; Nickrent, 2007).

Bdallophytum Eichler, Bot. Zeitung (Berlin) 30: 709. t. 8. 1872. *Scytanthus* Liebm., Förh. Skand. Naturf. Mote 4: 183. 1847 non *Skytanthus* Meyen 1834, nec Hooker WJ 1844. *Bdallophyton* Eichler, Engler & Prantl in, Nat Pflanzenfam. 3 (1): 281. 1889 var. orth. TYPE: *Bdallophytum andrieuxii* Eichler (here designated).

Parasitic dioecious or polygamo-monoecious with floral axes well developed, fleshy, unbranched, color cherry red to purple, sparsely to densely glandular pubescent, which gives them a yellowish-brown color. Inflorescence spiciform. Flowers unisexual or hermaphrodite, perianth irregularly segmented, campanulate, color cherry red to purple, black in a more mature stage, externally glandular pubescent. Ovary globose, with 7-12 placentas; stigma capitate, lobed. Berries globose or ovoid, sometimes concrescent, densely glandular pubescent; seeds with an ornamented testa, yellow. Chromosome number $n = 12$ (in *B. americanum*).

Diversity and distribution. Genus endemic to America with three species distributed from central Mexico to Costa Rica. All of them occur in Mexico, two of them are endemic.

Comments. In the original description of the genus, Eichler (1872) recognized two species: *B. andrieuxii* and *B. ceratantherum,* without defining the type. This paper refers to *B. andrieuxii* as the type species as *B. ceratantherum* which is now considered a synonym of *B. americanum.*

Bdallophytum is distinguished from *Cytinus* by its spiciform unbranched floral axis (*Cytinus* has solitary flowers or inflorescences in racemes or clusters), the flowers cherry red or purple (vs. yellow, red and white) and ornamented seeds (vs. smooth); the distribution of both groups do not overlap.

The specimens of this genus are sometimes poorly determined as with members of Orobanchaceae or Lennoaceae because of their holoparasitic habit, fleshy stems and purple flowers. However, both families are easily distinguishable from *Bdallophytum* by its pedicellate flowers, tubular or bilabiate corollas, free stamens, superior ovary and capsular fruits.

Key to the species

1. Inflorescences with fewer than 25 flowers; anthers generally straight, apical connective acuminate; berries globose, not concrescent ..... *B. americanum*

1. Inflorescences with 40 flowers; anthers curved, apical connective absent; berries ovoid concrescent.

2. Plants dioecious; anthers 8-14 (-18), irregularly arranged at the apex of the staminal column ..... *B. andrieuxii*

2. Plants polygamo-monoecious; anthers 4-8, in the hermaphrodite flowers these are opposite the stigma at the apex of the staminal column ..... *B. oxylepis*

Bdallophytum americanum (R. Br) Solms ex Eichler in Engler & Prantl, Nat Pflanzenfam 3 (1): 282. 1889 non *Bdallophyton americanum* (R. Br) Harms in Engler & Prantl, Nat Pflanzenfam. ed. 2, 16b: 281, 1935 nom. illeg. *Cytinus americanus* R. Br, Trans. Linn. Soc 19: 246. 1844. *Cytinus americanus.* Hook f. in DC. Prodr. 17: 108. 1873. pro part; *Scytanthus americanus* (R. Br) Solms in Engler, Pflanzenr. IV. 75 (Heft 5): 17. 1901. TYPE: "America aequinoctialis" nd, *A. Barclay sn.* (Holotype BM) (Fig. 2).

Scytanthus Bambusarum Liebm., Förh. Skand. Naturf. Mote 4: 177. 1847 *Bdallophyton bambusarum* (Liebm.) Harms in Engler & Prantl, Nat Pflanzenfam. ed. 2, 16b: 281. 1935. TYPE: (Mexico. Veracruz): Inter Pass Mail et Papantla, in June 1841, *Liebmann FM 1989* (holotype C; isotype GH).

Bdallophytum ceratantherum Eichler, Bot. Zeitung (Berlin) 30: 715. 1872 TYPE: Mexico. Bei der Nahe von Wartenberg in Tantoyuca, Provinz mexicanische Huazteca, 1858, *LC Ervendberg 101* (holotype not located in Herb. Boissier, probably in B (destroyed) or M).

Herbs 8-15.8 (-25) cm tall, dioecious; scales 0.5-1.5 x (3.4-) 4.5-6.3 mm, ovate-lanceolate, elliptic to spatulate, margins irregularly serrated or entire, fleshy, brown, glandular pubescent. Inflorescences with fewer than 25 flowers. Male flowers with bracts 3.3-6.7 x 4-6 mm, ovate, lanceolate or spatulate, serrate margin, reddish-brown to black; perianth 6-9-segmented, 6.5-10.9 mm high, 5-6.4 mm in diameter at the base, color cherry red to black; staminal column 1.4-2.7 (-3.5) mm long, anthers (6 -) 8-10 (-11) mm long, 2.7-3.3 mm wide, generally straight, annulus arranged at the apex of the column, apical connective 2-4.5 mm long, acuminate. Female flowers with bracts 5.5-9 (-10) x 3.9-5.5 mm, ovate or elliptical, serrated margin, brown to black; perianth 7-9-segmented, (4.7-) 5.8-11 mm high, 4.5-8.5 mm in diameter at the base, color cherry red, styles 3.5-6.5 mm long, stigmas 9-10-lobed, circular to oblong, yellow. Berries 1.2-1.5 cm diameter, not concrescent, brown; seeds 0.4-0.5 mm long.

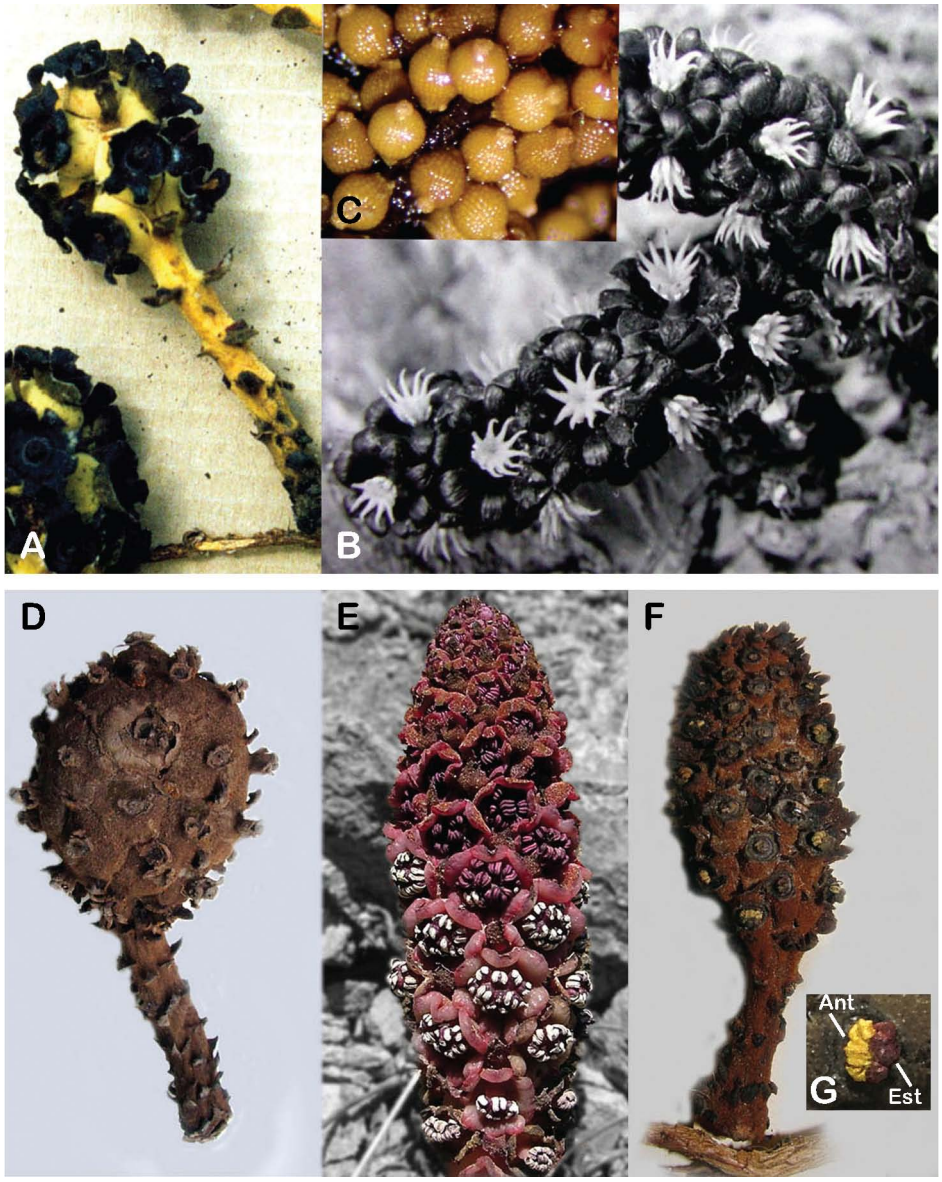

Fig 2. *Bdallophytum* spp. AC. *B. americanum:* A. - female individual (Photo by E. Carranza), B. male individual C. seeds. DE. *B. andrieuxii:* D. female individual E. male individual. *F-G. B. oxylepis:* F. individual polygamo-monoecious, G. hermaphrodite flower detail (Ant: anther; Est: stigma).

Distribution and ecology. The species is recorded from central Mexico (in the states of Aguascalientes, Durango, Guerrero, Jalisco, Mexico, Michoacan, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sinaloa, Tamaulipas and Veracruz) to Costa Rica (Gomez, 1983; Fig. 3). This taxon is found parasitizing different species of *Bursera,* but can also be found on *Gyrocarpus americanus* Jacq. *(Moreno 17068* (MEXU)), *Haematoxylum brasiletto* H. Karst. *(Pöll 5586* (MO photo collection)) and *Cochlospermum* Kunth species, *Ficus* L. and *Guazuma* Mill (Gomez, 1983), in vegetation of the tropical deciduous forest, evergreen and deciduous tropical forest and also in desert scrub at elevations of 80-1840 m asl. Flowering occurs mainly from April to

August and fruiting from August to November.

Common names and uses. In Guerrero is called "ground flower" (*Calónico 1099* (FCME)), in San Luis Potosi is called "Boo'waat wits" (Huastec) and attributed certain medicinal properties (*Alcorn 3252* (MEXU)).

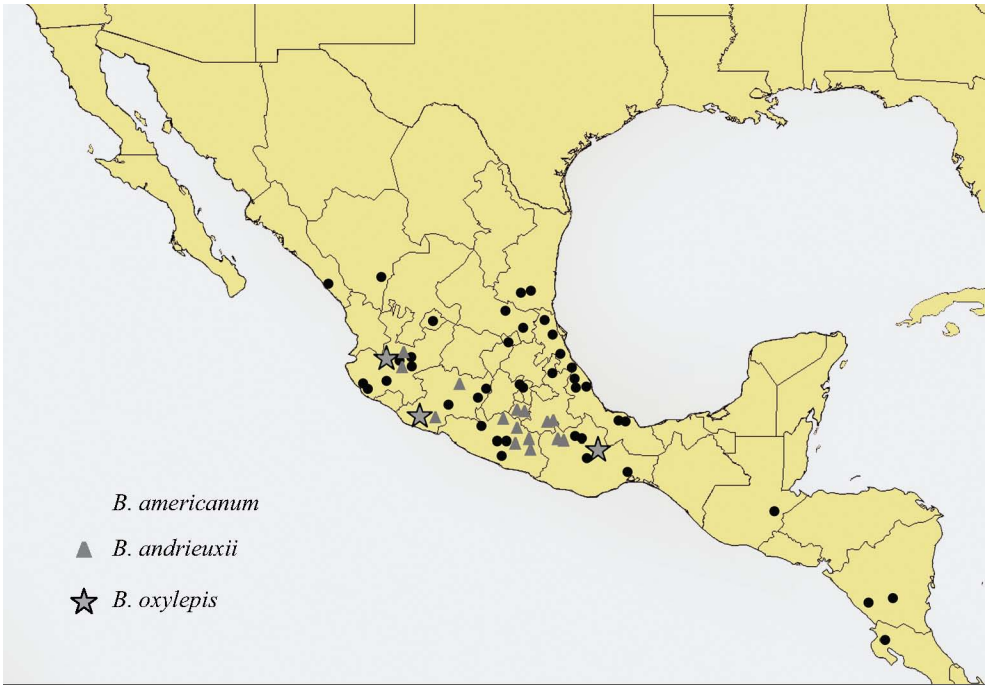

Fig 3. Distribution map *Bdallophytum americanum, B. andrieuxii* and *B. oxylepis.*

Specimens *examined.* GUATEMALA: Zacapa. Vicinity Pasabien, *Pöll 5586* (MO photo from the collection). MÉXICO: **Aguascalientes**. Mpio. Calvillo. Cañada los Adobes, *de la Cerda 6690* (MEXU). **Durango**. Mpio. Mezquital. 10 km SW de Mezquital, *Tenorio et al. 9597* (MEXU*). **Guerrero**. Mpio Eduardo Neri. La Yesera, 12.3 km al N de Zumpango del Río, *Calónico 1099* (FCME); 10 km N de Zumpango del Río, sobre carr. a Iguala, *Rzedowski 35812* (ENCB); Puente Mexcala, *Halbinger s.n.* (MEXU); Puente Mexcala, *Matuda y Halbinger s.n.* (MEXU); 83.5 km NE of Mex 200 jct in La Salitrera, on the way (Mex134) to Cd. Altamirano, *Yahara et al. 2237* (MEXU). **Jalisco**. Mpio. Bolaños. Rancho El Gallinero, 15 km NE de Bolaños, antes de llegar al crucero de Bolaños, carr. V. Guerrero-San Martín, *Flores et al*. *1840* (XAL). Mpio. Jocotepec. Barranca del Huarache, enfrente (SE) de Zapotitán de Hidalgo, *Machuca y Cházaro 7558* (XAL). Mpio. La Huerta. Estación de Biología Chamela, vereda Calandria, *Magallanes 4401* (MEXU). Mpio. Tuxcacuesco. Cerro del Palacio, 5-6 km WSW de Tuxcacuesco, 5-6 km ENE de Zenzontla, *Santana et al. 6468* (MEXU, ZEA); Cerro del Palacio, 5-6 km WSW de Tuxcacuesco, *Muñoz 6817* (MEXU, ZEA). Mpio. Zapopan. Cercanías del Puente Guadalupe, *De Puga 7422* (ENCB); Barranca los Tempisques, cercana a la ex hacienda El Lazo, *García-Larios y Puga s.n*. (MEXU). Mpio. sin definir. La Coyota o La Cortina, *Cuevas et al. 4656* (ZEA). **México**. Mpio. Tejupilco. Los Bejucos, *Matuda et al. 31378 a, b, c* (MEXU*). **Michoacán**. Mpio. La Huacana. Ca. 4 km (by road) SE of San Pedro Barajas, along Mex 37 W of El

Limoncito, *Steinmann 3080* (MEXU*). Mpio. Los Reyes. Barranca Los Chorros del Varal, *García y Cházaro 3671* (XAL). Mpio. Tuzantla. 5 km S de Paso de la Tierra Caliente, *González-Medrano et al. 4085* (MEXU). **Oaxaca**. Dto. Cuicatlán. Cerro Huarache Pintado, San José del Chilar, *Cruz-Espinosa y San Pedro 1069* (MEXU*); cerro El Zacatal, 4 km S de San José del Chilar, *Cruz-Espinosa et al. 1119* (MEXU); San Juan Bautista Cuicatlán, cerro El Zacatal, 4 km S de San José El Chilar, *Cruz-Espinosa et al. 1182* (MEXU*); 1.5 km en línea recta, S de Santiago Dominguillo, carretera Oaxaca - San Juan Bautista Cuicatlán, *Juárez-García et al. 776* (MEXU*); 5 km SE de San Juan Bautista Cuicatlán, desviación a San Pedro Jocotipac, *González-Medrano et al. F-1538* (ENCB, MEXU*); 9 km NE de San Juan Bautista Cuicatlán, rumbo a Concepción Pápalo, *González-Medrano et al. F-1700* (ENCB, MEXU*). Dto. Etla. El Progreso Sosola, camino real a La Calera (en el Cerro Buenavista), *Salinas y Flores 7368* (MEXU*); Cerro Buenavista, ca. 1 km N de El Parián, junto al río, *Salinas y Martínez-Correa 6239a* (MEXU*). Dto. Tehuantepec: Tehuantepec, *Matuda 587* (MEXU). **Puebla**. Mpio. San José Miahuatlán. Cerro Petlanco, *Salinas s.n.* (MEXU*); El Ajengibre, *Bravo s.n.* (MEXU). **Querétaro**. Mpio. Arroyo Seco. 2-3 km N de Mesa de Agua Fría, *Carranza 2194* (MEXU). **San Luis Potosí**. Mpio. Aquismón. Tancuime, *Alcorn 3252* (MEXU). Mpio. Ciudad del Maíz. Chupaderos, *Rzedowski 7751* (ENCB). **Sinaloa**. Mpio. Concordia. Paraje La Retumbadora, 5 km S de El Cuajote, *Guízar 3306* (MEXU). **Tamaulipas**. Mpio. Gómez Farías. 2 km N de Gómez Farías, *Díaz s.n.* (FCME); E of Los Cedros station, on W facing slope, *Seigler y Jones DS14039* (XAL); Aprox. 2 km E de Gómez Farías, Sierra Chiquita, *Valiente y Viveros 228* (ENCB, MEXU, XAL); aprox. 3 km W de Gómez Farías, *Valiente et al. 313* (MEXU); 12 km SSW del poblado Gómez Farías, Bocatoma. Cerca de la estación meteorológica Ahualulco de la SAHR, *Valiente et al. 483* (MEXU). **Veracruz**. Mpio. Actopan. Cerro de La Mesa (Sierra de Manuel Díaz), *Acosta y Calzada 955* (XAL); ejido Villa Rica, *Acosta y Vázquez 638* (XAL); playa Cansa Burros, 2 km S de la Mancha, *Acosta y Vázquez 789* (XAL); Villa Rica, cerca de Villa Rica, *García 614* (XAL); Estación Biológica El Morro de la Mancha, *Guerrero 1748* (XAL). Mpio. Dos Ríos. Cerro Gordo, *Ventura 1502* (MEXU); La Cumbre, *Ventura 4005* (ENCB). Mpio. Emiliano Zapata. 1/2 km de la desv. a Ca rrizal, carr. Xalapa, *Calzada 1829* (XAL). Mpio. La Antigua. El Rincón del Pirata, *Ventura 14932* (ENCB, MEXU, XAL). Mpio. Martínez de la Torre. Ixtacuaco, *Ventura 19674* (ENCB, MEXU*); Cañadas, *Ventura 19798* (ENCB). Mpio. Ozuluama. Camino la Laja-Ozuluama, km 14, *Chiang 99* (MEXU). Mpio. Pánuco. Cerro Topila, ejido Benito Juárez, *Gutiérrez y Guerrero 1997* (MEXU*). Mpio. Papantla. 2 km delante de Papantla, *Vázquez 1155* (XAL). Mpio. Paso de Ovejas. Camino a Acasónica, 2 km antes de Acasónica, *Vázquez 575* (XAL). Mpio. Puente Nacional. Barranca de Pachuquilla, 2 km SW de dicha población, *Medina y Vázquez 439* (MEXU, XAL). Mpio. San Andrés Tuxtla. N and E sides of Laguna Encantada, 3 km NE of San Andrés Tuxtla, *Nee et al. 24751* (ENCB, MEXU, XAL); Laguna Encantada, ca. 3 km of Sn. Andrés Tuxtla, San Andrés Tuxtla, *Dressler y Jone*s *137* (MEXU); E of Sn Andrés Tuxtla, *Dressler y Jones 138* (MEXU). Mpio. Tepetzintlán. San José de Copaltitlan, 7 km NE de Tepetzintlán, *Castillo y Benavides 2579* (XAL). Mpio. Yecuatla. La Independencia, orilla W del poblado, dirección Arroyo Burro, *Gutiérrez 3767* (MEXU). Cerro Monte de Oro, *Dorantes et al. 924* (MEXU*). NICARAGUA: **Chontales**. Hda. Corpus, 2 km S of the hwy between El Guasimo and Juigalpa, *Miller et al. 1057* (MEXU*); Hacienda Corpus, 11 km W of Juigalpa, *Miller y Nee 1384* (ENCB, MEXU*); Hda. Corpus, W of Juigalpa, *Stevens 21780* (MEXU*, MO foto de la colecta). **Granada**. Casa Tejas, 21 km de la carr. Nandaime-Granada, *Moreno 17068* (MEXU). *Comments.* The combination *Bdallophytum americanum* (based on *Cytinus americanus*) is commonly awarded to Harms (1935), but it is not

legitimate because it is a later homonym that was proposed by Solms-Laubach (1889), who recognizes the species *B. andrieuxii* and *B. americanum,* for what I would consider to *B. ceratantherum* Eichler latter synonymously.

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The type specimen corresponding to *B. ceratantherum* was not found in the herbarium at Geneva (G), as indicated in the protologue; it could possibly be in any of the herbaria where Eichler worked and was not returned in time to De Candolle herbarium. The above mentioned name is here corroborated as a synonym of *B. americanum*, as previous authors have considered (Solms-Laubach, 1889; Harms, 1935; Kuijt, 2001), because the characteristics of the androecium in *B. ceratantherum* mentioned in the original description, correspond to that of *B. americanum*.

García-Franco and Rico-Gray (1997b) observed in the tropical region of Los Tuxtlas, Veracruz, that the fruits of *B. americanum* are consumed by the rodent *Peromyscus mexicanus mexicanus*, but given the fact that the distribution of this rodent is restricted to neovolcanic areas (Ceballos, 2005), there should be other mammals and/or insects that are responsible for the spread of the parasite in other sectors of our area.

Bdallophytum andrieuxii Eichler, Bot. Zeitung (Berlin) 30: 715, t. 8. 1872 ; *Cytinus andrieuxii* (Eichler) Hemsl., Biol. Cent.-Amer., Bot . 3: 41. 1882; *Hypocistis andrieuxii* (Eichler) Kuntze, Revis. Gen. Pl. 2: 563. 1891; *Scytanthus andrieuxii* (Eichler) Solms in Engler, Pflanzenr. IV. 75(5): 18. 1901; *Cytinus americanus* Hook. f. in DC., Prodr . 17: 108. 1873. pro parte. TIPO: México. Oaxaca: in Sylvis Ditionis Oaxacanae, between Huauapan (Huajuapam) & Oaxaca, June 1834, *G. Andrieux 50* (holotype G-DC!; isotype K!). (Fig. 2).

Herbs 10-12.5 cm high, dioecious; scales 1.6-4.5 (-4.8) x 1.4-3.8 mm, ovate to lanceolate, margin irregularly serrated or entire, succulent, brown to purple, glabrous to glandular pubescent. Inflorescences with 40 flowers. Male flowers with bracts (2.1-) 4.2-6.6 x 1.3-3.8 (5.6) mm, ovate to spatulate, serrate margin, purple to black; perianth 5-7-segmented, 2.9-3.8 mm high, 3.2-3.5 mm in diameter base, purple; staminal column 1-3 mm long, anthers 5-14 (-18), 1-2.1 mm long, usually curved, irregularly arranged in the apex of the column, apical connective absent. Female flowers with bracts 3.3-5.5 x 1.8-4 mm, with a serrated margin, purple, glandular pubescent, perianth segments 5-7, 3-4.3 mm high, (2 -) 3-6.7 (-8) mm diameter the base, purple, styles 0.9-1.5 mm long, stigmas 8-12-lobed, oblong, probably yellow. Berries 0.8-1.2 cm diameter, concrescent, brown, seeds 0.3-0.4 mm long.

Distribution and ecology. Species endemic to Mexico, present in the states of Guerrero, Michoacan, Morelos, Puebla and Oaxaca (Fig. 3). This taxon is found parasitizing *Bursera aloexylon* (ex Schiede Schltdl.) Engl. (Castro and Villegas 1136, Valenzuela 1 (HUMO)) and other species of *Bursera* and on *Juniperus* (Alvarado-Cárdenas and Sandoval sn (MEXU)) in tropical deciduous forest and desert scrub at elevations of 1173-1410 m. Flowering and fruiting is recorded for June and July.

Common names. In Guerrero and Michoacán it is called “flor de tierra” (*Calónico 1031* (FCME) & *Armas sn* (MEXU)) and in Morelos “mojón de gañán” (*Castro y Villegas 1136* (HUMO)).

Specimens examined . MÉXICO: **Guerrero** : Mpio. Alpuyeca. 0.5 km al E de Tecoyo, *Calónico 408* (FCME); 0.5 km al SW de Tecoyo, *Calónico 1810* (FCME). Municipality. Eduardo Neri. Amatitlán, *Calónico 1031* (FCME); Axaxacoalco, 1 km al W, *Valencia 1193* (FCME), *1194* (FCME); cañada del Zopilote, *Bravo sn* (MEXU*). Municipality. Huamuxtitlán. 6 km (15 grados) SE de Huamuxtitlán hacia Cualac, *Limón 74-III* (FCME); 6 km (15 grados) SE de Huamuxtitlán hacia Tlaquiltepec, *Soto 658* (FCME). Municipality. Mina. Trincheras, *Hinton et al. 10134* (G); Mina, *sin colector sn* (MEXU*). Municipality. Xochihuehuetlán. Paraje Ocotepec, 2.75 km NNW de Jilotepec, Cerro Xilotzin, *Moreno 956* (FCME). Municipality. Zicapa. 8 km al N de Zicapa, *Monzon sn* (FCME). **Jalisco** : Mpio. Guadalajara. Barranca de Huentitán El Alto, parte alta de los alrededores del templo, *Macías 896* (ENCB). Municipality. Zapopan. W del Cerro El Mexicano, Barranca los Tempisques, cercana a la exhacienda El Lazo, *García-Larios sn* (ENCB). **Michoacán** : Mpio. Apatzingán. Apatzingán, *Hinton 12012* (ENCB). Municipality. Arteaga, Potrero para el ganado, *Armas sn* (ENCB, MEXU*, XAL); potrero El Puerto, *Armas sn* (ENCB). **Morelos** : Mpio. Amacuzac. El Cristo, 10 km N de los límites estatales, entre Morelos y Guerrero, *García-Mendoza et al. 6527* (MEXU). Municipality. Puente Ixtla. A 1 km al S de Tilzapotla, *Juárez y Bustamante 1039* (HUMO). Municipality. Tlalquiltenango. A 7 km al NW de Huautla, *Castro y Villegas 1136* (HUMO); 5 km de Xochipala, *Cerros et al. 1065* (HUMO); *1071* (HUMO); Tlalquiltenango, *Miranda 1483* (MEXU*); El Limón de Cuachichinola, *Valenzuela 1* (HUMO). **Oaxaca** : Dto. Huajuapam: terracería entre Tultitlán de Guadalcázar y San Miguel Ixtapa, *Guízar* y *Herrera 4065* (MEXU*); in Sylvis Ditionis Oaxacanae, inter Huauapan (Huajuapam) et Oaxaca, *Andrieux 50* (G, K*). **Puebla** : Mpio. Caltepec. Cerros a 1 km W del poblado de San Juan Acatitlán, *Alvarado-Cárdenas* y *Sandoval sn* (MEXU*). Municipality. Izúcar de Matamoros. Entrada a la estación de MO Raboso, aprox. 9 km S de Raboso, carr. I. De Matamoros-Huajuapan de León, *Panero et al. 5762a* (MEXU*).

Comments. Female individuals of this species have been determined erroneously as *Bdallophytum americanum*, but can be easily identified because *B. andrieuxii* has a greater number of flowers and the fusion of the ovaries during fruiting is very evident (Fig. 2).

Bdallophytum oxylepis (BL Rob.) Harms in Engler & Prantl, Nat. Pflanzenfam. ed. 2, 16b: 281. 1935; *Cytinus oxylepis* BL Rob., Proc. Amer. Acad. Arts 29: 321. 1894. TYPE: México. Jalisco. Zapotlán, 13-27 May 1893, *CG Pringle 4373* (holotype GH; isotypes MEXU!, MO foto!, NY photo!, US photo!) (Fig. 2).

Herbs 6.1-11 cm high, polygamo-monoecious; scales 2.3-4.5 x 2-2.2 mm, ovate, margin irregularly serrated to crenate, succulent, brown to purple, glandular pubescent. Inflorescences with 40 flowers. Female flowers with bracts 2.3-4 x 1.5-2.0 mm, with a serrated margin, purple, glandular pubescent, 5-7 perianths-segmented, 2.5-3 mm high, 2.6-3.5 mm in diameter at the base, purple, style 1-1.6 mm long, stigmas 8-12-lobed, oblong, probably yellow. Hermaphrodite flowers with bracts (1.6-) 3.3-4 x 1.5-2.4 mm, ovate, with a serrated margin, purple to black, glandular pubescent, 5-7 perianth-segmented, 2.7-3 mm high, 2.6-3.5 mm in diameter the base, purple, staminal column 1.1-1.6 mm long, anthers (2 -) 4-7 (-10), 1.1-1.6 mm long, usually

curved, annular and arranged opposite to the stigma at the apex of the column, apical connective absent; styles 1.1-1.6 mm long, stigmas 8-12-lobed, oblong, probably yellow. Berries 5.5-7.5 mm long, ?? mm diameter, ovoid, concrescent, brown, seeds 0.3-0.4 mm long.

Distribution and ecology. Species endemic to Mexico collected only in the states of Jalisco, Michoacan and Oaxaca. (Fig. 3). The only taxon found parasitizing *Bursera* species in tropical deciduous forest vegetation and desert scrub at elevations of 950 to 1200 m asl. Flowering and fruiting occurs from May to August.

Specimens examined. MÉXICO: **Jalisco** : Mpio. Ciudad Guzmán. Zapotlán, *Pringle 4373* (MEXU*). **Michoacán** : Mpio. Coalcomán. Salitre, *Rzedowski 16712* (ENCB, MEXU*). **Oaxaca** : Mpio. sin definir. 5 km NW de Santa María Laxizanace, *Reyes 1901* (MEXU*).

Comment. This species is very similar to *Bdallophytum andrieuxii* because it has no apical anther connective and the fruits are concrescent, but it is easy to separate, the latter being the only representative of the genus with hermaphroditic and unisexual female flowers on the same individual.

CONCLUSIONS

The pattern of ordination obtained from the analysis performed for the specimens of the genus *Bdallophytum* allowed the recognition of three species: *B. americanum*, *B. andrieuxii* and *B. oxylepis* (Fig. 2). The subordination of *B. bambusarum* and *B. ceratantherum* as synonyms of *B. americanum* proposed by some authors (Solms-Laubach, 1889; Kuijt, 2001; Carranza-Gonzales, 2002) is confirmed in this analysis (Fig. 1). Moreover, Gomez (1983) considered this genus as monotypic, recognizing only *B. americanum*, mentioning that it did not appear relevant to recognize the other described species as independent entities. However, it is likely that Gomez (1983) observed no other material components of genus in other collections, since there are obvious differences not only in the size of the inflorescence but also the fusion of the fruits. According to this analysis, the main differences between the species lies in the arrangement and shape of the anthers, the number of flowers per inflorescence, the presence of unisexual or hermaphrodite flowers and the length and color of the perianth. The evidence so far solves the problem of the identity and number of entities in this genus. However, there is still work to do at the phylogenetic level, which include all species *Bdallophytum* and its sister group *Cytinus* that would allow us to generate robust hypotheses of relationships of these taxa.

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