Tigridieae (Iridaceae) in North America: floral diversity, flower preservation methods and keys for the identification of genera and species

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Abstract

Background: The tribe Tigridieae (Iridaceae) is a monophyletic group restricted to America. It includes bulbous perennial plants with plicate and isobilateral leaves. The inflorescence is a rhipidium and the floral structures are fugacious, very variable in shape, color and size. Tigridieae is taxonomically and morphologically complex. Its generic limits are unresolved and the vegetative uniformity of the tribe complicates species identification. Species are recognized by the position, shape and color of the tepals, stamens and stigma, characters that are difficult to observe in many herbarium specimens.
Studied species: Sixty-seven species of the tribe Tigridieae.
Study site and years of study: North America (Canada, United States of America and Mexico). The study was conducted from 2009 to 2015.
Methods: Twenty-three herbaria, floristic studies and monographs were reviewed and specimens were collected in the field. Fresh dissections were performed in order to preserve the flowers and an analysis was conducted of the floral variation and distribution of the species of Tigridieae.
Results: Keys for the identification of genera and species are presented. Photographs of the species and floral structures are included for their recognition. In addition, a method is described for dissecting and preserving flowers as herbarium specimens. Finally, geographic distribution data are presented.
Conclusions: In North America, 67 species within14 genera of Tigridieae are known, of which 54 are endemic. Tigridieae exhibits wide floral diversity influenced by its pollinators and geographic isolation. This key for the Tigridieae of North America along with the photographs illustrating floral diversity will facilitate identification of species in the field.

Keywords: Mexico, key, floral dissections, distribution, biodiversity, floral diversity.

Tigridieae (Iridaceae) en Norteamérica: diversidad floral, métodos de preservación de sus flores y claves para identificación de géneros y especies

Resumen

Antecedentes: La tribu Tigridieae (Iridaceae) es un grupo monofilético restringido a América. Incluye a plantas bulbosas y perennes, con hojas plegadas e isobilaterales, inflorescencia en forma de ripidio, estructuras florales fugaces, muy variables en forma, color y tamaño. Tigridieae es complicada morfológica y taxonómicamente. Sus límites genéricos no están resueltos y su uniformidad vegetativa dificulta la identificación de las especies. Las especies son reconocidas por la posición, forma, tamaño y color de los tépalos, estambres y estigma, caracteres difíciles de observar en ejemplares de herbario.
Especies en estudio: 67 especies de la tribu Tigridieae.
Sitio de estudio y fechas: Norteamérica (Canadá, Estados Unidos de América y México). El trabajo se realizó de 2009 a 2015.
Métodos: Se revisaron 23 colecciones botánicas, trabajos botánicos y se colectaron ejemplares en campo. Se realizaron disecciones en fresco para preservar las flores y se analizó la diversidad floral y distribución de las especies de Tigridieae.
Resultados: Se presenta una clave para la identificación de géneros y otra para especies. Se incluyen fotografías de las especies y de las estructuras florales para su reconocimiento. Además, se describe un método para disectar y preservar las flores como ejemplares de herbario. Finalmente, se presentan datos sobre su distribución en esta área.
Conclusiones: En Norteamérica crecen 14 géneros y 67 especies de Tigridieae, de las cuales 54 son endémicas. Tigridieae exhibe una gran diversidad floral promovida por sus polinizadores y el aislamiento geográfico. El contar con una clave de las Tigridieae de Norteamérica y fotografías de su diversidad floral contribuye con su identificación en campo.

Palabras clave: México, clave, disecciones florales, distribución, biodiversidad, diversidad floral.

The family Iridaceae is distributed in temperate and tropical climates, but its highest diversity is found in Southern Africa and Central and South America (Goldblatt *et al*. 1998). The family presents leaves with a bifacial base and unifacial or bilateral blade. The flowers have three stamens and, except in the genus, *Isophysis* T. Moore, the ovary is inferior (Goldblatt *et al*. 2008). Iridaceae includes plants of ornamental importance in the genera *Crocosmia* Planch., *Freesia* Klatt, *Gladiolus* L., *Iris* L. and *Watsonia* Mill. It also includes *Crocus sativus* L., from which saffron is obtained.

Iridaceae is distinguished into seven subfamilies: Isophysidoideae Takhtajan ex Torne & Reveal, Patersonioideae Goldblatt, Geosiridoideae Goldblatt & J. C. Manning, Aristeoideae Vines, Nivenioideae Goldblatt, Crocoideae G. T. Burnett and Iridoideae Pax (Goldblatt *et al*. 2008). In turn, the subfamily Iridoideae is divided into the tribes Diplarreneae Goldblatt, Irideae B. M. Kittel, Sisyrinchieae J. S. Presl, Trimezieae Ravenna and Tigridieae B. M. Kittel (Goldblatt *et al*. 2008). Tigridieae is a monophyletic group comprising approximately 172 species (Rodríguez & Sytsma 2006, Goldblatt *et al*. 2008).

Members of the tribe Tigridieae produce bulbs, plicate and isobilateral leaves, rhipidia, two series of three tepals that are very variable in shape, color and size, pyriform capsules and seeds. One typical characteristic of Tigridieae is the variability exhibited by the branches of the style. These, together with the stamens, form a complex and specialized structure (Goldblatt & Henrich 1991). Such complexity and variability contrasts with the vegetative uniformity of the group. Goldblatt (1982) divided Tigridieae into the subtribes Cipurinae Benth. & Hook., and Tigridiinae Pax. Species in Cipurinae are characterized by presenting monosulcate pollen (Rudall & Wheeler 1988), simple and thickened style branches, free stamens and a base number of chromosomes equal to seven (x = 7) (Goldblatt, 1982). In contrast, the pollen grains of Tigridiinae are bisulcate (Rudall & Wheeler 1988), the style branches are bifid, the stamen filaments are fused and the base number of chromosomes is 14 (x = 14) (Goldblatt 1982). However, phylogenetic analyses of Tigridieae based on DNA sequences do not support this hypothesis (Rodríguez & Sytsma 2006, Goldblatt *et al*. 2008, Chauveau *et al*. 2012).

Tigridieae is restricted to the American continent. Its species are distributed in South, Central and North America and on the Islands of the Caribbean. According to level 1 of the TDWG (International Working Group on Taxonomic Databases for Plant Sciences), North America includes Canada, United States of America and Mexico (Brummitt 2001). In this area, there are 14 genera and 67 species, of which 54 are endemic. The genera present are: *Ainea* Ravenna, *Alophia* Herb., *Cardiostigma* Baker, *Cipura* Aubl., *Cobana* Ravenna, *Colima* (Ravenna) Aarón Rodr. & L. Ortiz-Cat., *Eleutherine* Herb., *Fosteria* Molseed, *Herbertia* Sweet, *Larentia* Klatt, *Nemastylis* Nutt., *Salpingostylis* Small, *Sessilanthera* Molseed & Cruden and *Tigridia* Juss. Its geographic distribution presents two patterns: in the first, *Alophia*, *Cipura*, *Colima*, *Eleutherine*, *Herbertia*, *Larentia*, *Nemastylis* [except *N. tenuis* Baker] and *Salpingostylis* are distributed throughout the coastal plains of the Gulf of Mexico and Pacific Ocean. In the second, *Ainea*, *Cobana*, *Cardiostigma*, *Fosteria*, *Sessilanthera*, *Tigridia* and *N. tenuis* are found in the Balsas Basin, the Transmexican Volcanic Belt, Chiapas Highlands, Sierra Madre del Sur, Sierra Madre Occidental and Sierra Madre Oriental (Munguía-Lino *et al*. 2015a).

Mexico is a center of diversification of Tigridieae. There are 63 species within Mexican territory and the greatest richness and diversity is concentrated in the states of Jalisco, Mexico, Michoacán and Oaxaca. In the USA, six species are known; *Nemastylis floridana* Small, *N. geminiflora* Nutt., *N. nutalli* Pickering ex R.C. Foster, *N. tenuis*, *Herbertia lahue* (Molina) Goldblatt ssp. *caerulea* (Herb.) Goldblatt and *Salpingostylis coelestina* (W. Bartram) Small. The elevational range of Tigridieae is from sea level to 3,500 m, with most diversity between 2,000 and 2,250 m asl. This elevation range coincides with the pine-oak forest distribution (Munguía-Lino *et al*. 2015a).

Tigridieae is a potentially useful group. The bulbs of *Tigridia ehrenbergii* (Schltdl.) Molseed ssp. *ehrenbergii*, *T. augusta* Drapiez, *T. mexicana* Molseed ssp. *mexicana* and *T. pavonia* (L.f.) DC are consumed in some communities of the states of Mexico, Oaxaca and Puebla. Furthermore, the medicinal use of *Tigridia pavonia* has been recorded. Due to the size, shape, structure and color of its flowers, they have ornamental value and already *Tigridia pavonia* and *Eleutherine bulbosa* Urb., are used for this purpose. In Mexico, plants of Tigridieae are known

commonly as *cacomite*, *cebollaje*, *flor del tigre*, *flor de un día*, *flor de la trinidad*, *flor de hueso*, *flor de pañuelo*, *guaquique*, *jahuite*, *jirafita*, *juique*, *palmita*, *oceloxóchitl* and *rodilla de Cristo* (Hernández 1959, Rodríguez & Ortiz-Catedral 2001, Vázquez-García 2011).

In North America, Tigridieae has been the subject of taxonomic and floristic studies: Foster (1945), Molseed (1970), Cruden (1971), Espejo-Serna & López-Ferrari (1996a, 1996b, 1998), Rodríguez & Ortiz-Catedral (2001), Goldblatt (2002) and Espejo-Serna *et al*. (2010). These include morphological descriptions, keys for identification, drawings and some color photographs. However, none of these include all the North American species of Tigridieae. Furthermore, the group is very complex and poorly represented in the herbaria and most specimens lack well-preserved floral structures. Separation of the genera and the species is a based on the position, shape and color of the tepals, stamens, style and stigma. Accurate determinations are complicated since these characteristics are difficult to appreciate in many herbarium specimens.

Given the lack of a study that encompasses the Tigridieae of North America, the objective of the present study is to analyze the floral variability of the tribe in North America and to present a key for the 71 taxa (65 species and 6 subspecies). Photographs of the species are included to facilitate their recognition. Furthermore, a method is described for dissecting and preserving the floral structures of Tigridieae as herbarium specimens. Finally, geographic distribution data are presented.

Materials and methods

Morphological and geographic data were obtained from the revision of specimens from 23 botanical collections: Herbario de la División de Ciencias Forestales, Universidad Autónoma Chapingo (CHAP); Herbario-Hortorio de Botánica, Colegio de Postgraduados (CHAPA); Herbario Eizi Matuda, Facultad de Ciencias Agrícolas, Universidad Autónoma del Estado de México (CODAGEM); Herbario del Instituto Tecnológico Agropecuario de Jalisco (CREG); Herbario CICY, Unidad de Recursos Naturales, Centro de Investigación Científica de Yucatán, A.C. (CICY); Herbaria of the Centros Interdisciplinarios de Investigación para el Desarrollo Integral Regional, Instituto Politécnico Nacional, in Durango (CIIDIR), in Michoacán (CIMI) and in Oaxaca (OAX); Herbario de la Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional (ENCB); Herbario de la Facultad de Ciencias, Universidad Nacional Autónoma de México (FCME); Herbario y Jardín Botánico de la Universidad Autónoma de Guadalajara (GUADA); Herbario de la Universidad Autónoma del Estado de Morelos (HUMO); Herbario Luz María Villarreal de Puga, Instituto de Botánica de la Universidad de Guadalajara (IBUG); Herbario del Instituto de Ecología, A.C., Centro Regional del Bajío (IEB); Herbario Iztacala, Facultad de Estudios Superiores, Universidad Nacional Autónoma de México, Iztacala (IZTA); Herbario Nacional del Instituto de Biología, Universidad Nacional Autónoma de México (MEXU); Herbario de la Sociedad para el Estudio de los Recursos Bióticos de Oaxaca, A.C. (SERO); Herbario del Instituto de Investigación Científica, Universidad Autónoma de Guerrero (UAGC); Herbario Metropolitano Ramón Riba y Nava Esparza, Universidad Autónoma Metropolitana, Iztapalapa (UAMIZ); Herbario J. Rzedowski, Universidad Autónoma de Querétaro (QMEX); Herbario del Instituto de Ecología, A.C., Xalapa (XAL); Herbario de la Universidad Veracruzana (XALU), and Herbario del Centro Universitario de la Costa Sur, Universidad de Guadalajara (ZEA) (Thiers 2015).

In addition, a review was conducted of material and type specimens of some virtual herbaria such as: University of Arizona Herbarium (ARIZ); National Herbarium of Canada, Canadian Museum of Nature (CANM); Herbarium of the California Academy of Sciences (CAS); AAFC National Collection of Vascular Plants, Agriculture and Agri-Food Canada (DAO); Herbarium of the Biology Department, Duke University (DUKE); Herbarium of the Botany Department, Field Museum of Natural History (F); Herbarium of the Florida Museum of Natural History, University of Florida (FLAS); Gray Herbarium, Harvard University (GH); Kew Herbarium, Royal Botanic Gardens (K); the University of Texas Lundell Herbarium (LL-TEX); Herbarium of the University of Michigan (MICH); Missouri Botanical Garden Herbarium (MO); Erbario, Università di Messina (MS); William and Lynda Steere Herbarium, New York Botanical Garden (NY); Herbarium of the University of Texas at Austin (TEX); University Herbarium, University

of California, Berkeley (UC); Dunn-Palmer Herbarium, University of Missouri (UMO); United States National Herbarium, Smithsonian Institution (US), and Wisconsin State Herbarium, University of Wisconsin (WIS) (Thiers 2015).

The protologs and morphological descriptions of species included in monographs, floras and taxonomic studies were reviewed (Foster 1945, Cruden 1968, 1971, 1975, Molseed 1968, 1970; Molseed & Cruden 1969, Goldblatt & Henrich 1987, McVaugh 1989, Henrich & Goldblatt 1994, Espejo-Serna & López-Ferrari 1996b, 1998, Calderón de Rzedowski & Rzedowski 2001, Rodríguez & Ortiz-Catedral 2003a, 2003b, Ravenna 1974, 1979, Rodríguez *et al*. 2003, Rodríguez & García-Mendoza 2004, Rodríguez & Ortiz-Catedral 2005a, 2005b, 2006 and Espejo-Serna *et al*. 2010).

In order to collect botanical specimens, observe species in their habitat, analyze floral structures, obtain photographs and record phenologies, a total of 40 field explorations were conducted between 2009 and 2015. Collections were made in 200 locations of 17 Mexican states: Chiapas, Colima, Guerrero, Hidalgo, Jalisco, Estado de México, Michoacán, Morelos, Nayarit, Oaxaca, Puebla, Querétaro, San Luis Potosí, Tamaulipas, Tlaxcala, Veracruz and Ciudad de México. Specimen collection followed standard protocols used by botanists and collectors (Lot & Chiang 1986). Collection routes were designed based on the review of herbarium specimens, monographs, floras and taxonomic studies.

Live plants, bulbs and seeds were also obtained and these were cultivated in the Centro de Conservación de Plantas Silvestres of the Universidad Autónoma del Estado de México and the Jardín Botánico Didáctico of the Instituto de Botánica, Centro Universitario de Ciencias Biológicas y Agropecuarias of the Universidad de Guadalajara.

Results and discussion

A total of 3,481 herbarium specimens were reviewed. In the field, 286 populations were collected and photographs were obtained of 59 species of Tigridieae. These include bulbs fruits and seeds (Figure 1) and the morphological and color variability of the flowers (Figures 2-6) that provide important details for the recognition of species.

In North America, there are 14 genera and 67 species belonging to Tigridieae (Table 1). The highest species richness is concentrated in the Mexican states of Jalisco, Mexico and Oaxaca. Detailed analyses of the areas and distribution patterns of most North American species, as well as additional images of the flowers, are presented in Munguía-Lino *et al*. (2015a). From the compiled and analyzed information, two keys were produced: one to identify genera and the other for species of Tigridieae in North America. Keys were based on floral morphology and geographic data (Table 1). The method of preservation of the floral material was efficient since it enabled the preparation of herbarium samples with floral structures which exhibit the forms and colors of these plants when fresh (Figure 7).

Floral variability of Tigridieae. As has already been mentioned, it is very difficult to identify the genera and species of Tigridieae without fresh and open flowers. In contrast to the vegetative uniformity of the tribe, the flowers are very variable (Figures 2-6). Their position is erect, secund or nutant; *i.e*. the frontal face of the flowers can be oriented upwards, downwards or laterally. There are two series of three tepals each: the exterior and the interior. Sometimes, the basal and distal parts are different, these known as the claw and the limb, respectively.

Tepal size is variable. In general, the exterior tepals are larger than the interior, although occasionally they are subequal or the interior tepals have a very reduced limb. Tepals can be all white, yellow, blue, red, purple, pink or yellowish-white, concolorous but more frequently they have different coloration patterns. Tepals vary between maculate, striate or variegated. It is common to observe bicolorous tepals, in which the base is light and the distal part is dark. Usually the exterior and interior tepals are extended but in *Fosteria* (Figures 3F-G) and *Tigridia* (Figures 4D-Y and 5-6), the basal part forms a structure that looks like a cup of variable depth.

In Tigridieae, the tepals may have nectaries, but these are variable (Rudall *et al*. 2003, Chauveau *et al*. 2012). Nectaries are found on the adaxial surface of the exterior or interior tepals or on both. In one type, the nectiferous area is covered with sugar-secreting trichomes while in the other, the trichomes secrete oil. In *Tigridia* and *Fosteria*, the nectaries appear in the

Figure 1. Morphological variability of the genera of Tigridieae. Bulbs: **A)** *Cipura campanulata*, **B)** *Eleutherine latifolia*, **C)** *Colima convoluta*, **D)** *Nemastylis tenuis*, **E)** *Tigridia galanthoides*, **F)** *Tigridia flammea*. Fruits: **G)** *Ainea conzattii*, **H)** *Alophia silvestris*, **I)** *A. veracruzana*, **J)** *Cardiostigma longispatha*, **K)** *Cardiostigma hintonii*, **L)** *Cipura campanulata*, **M)** *Colima convoluta*, **N)** *Eleutherine latifolia*, **O)** *Nemastylis tenuis*, **P)** *Sessilanthera citrina*, **Q)** *Tigridia estelae*, **R)** *T. galanthoides*, **S)** *T. martinezii*, **T)** *T. orthantha*. Seeds: **U)** *A. intermedia*, **V)** *A. drummondii*, **W)** *Cardiostigma hintonii*, **X)** *C. campanulata*, **Y)** *Colima tuitensis*, **Z)** *E. latifolia*, **A')** *Fosteria oaxacana*, **B')** *Larentia rosei*, **C')** *N. tenuis*, **D')** *S. latifolia*, **E')** *T. ehrenbergii*. Photographs of Aarón Rodríguez (G-R, T), Guadalupe Munguía Lino (U-E'), Munguía-Lino *et al*. 2015a (S) and Luis Miguel Vázquez García (A-F).

Figure 2. Morphological and color variability in flowers of Tigridieae. **A-B)** *Ainea conzattii*, **C-E)** *Alophia drummondii*, **F-G)** *A. intermedia*, **H-J)** *A. silvestris*, **K-M)** *A. veracruzana*, **N-O)** *Cardiostigma hintonii*, **P-R)** *C. longispatha*, **S-T)** *C. mexicana*, **U-V)** *Cipura campanulata*, **W-X)** *Cobana guatemalensis*, **Y-Z)** *Colima convoluta*. Photographs of Aarón Rodríguez (C-P, W-X, Z), Guadalupe Munguía Lino (A-B, S-V) and Rodríguez & Ortiz-Catedral 2003a (Y).

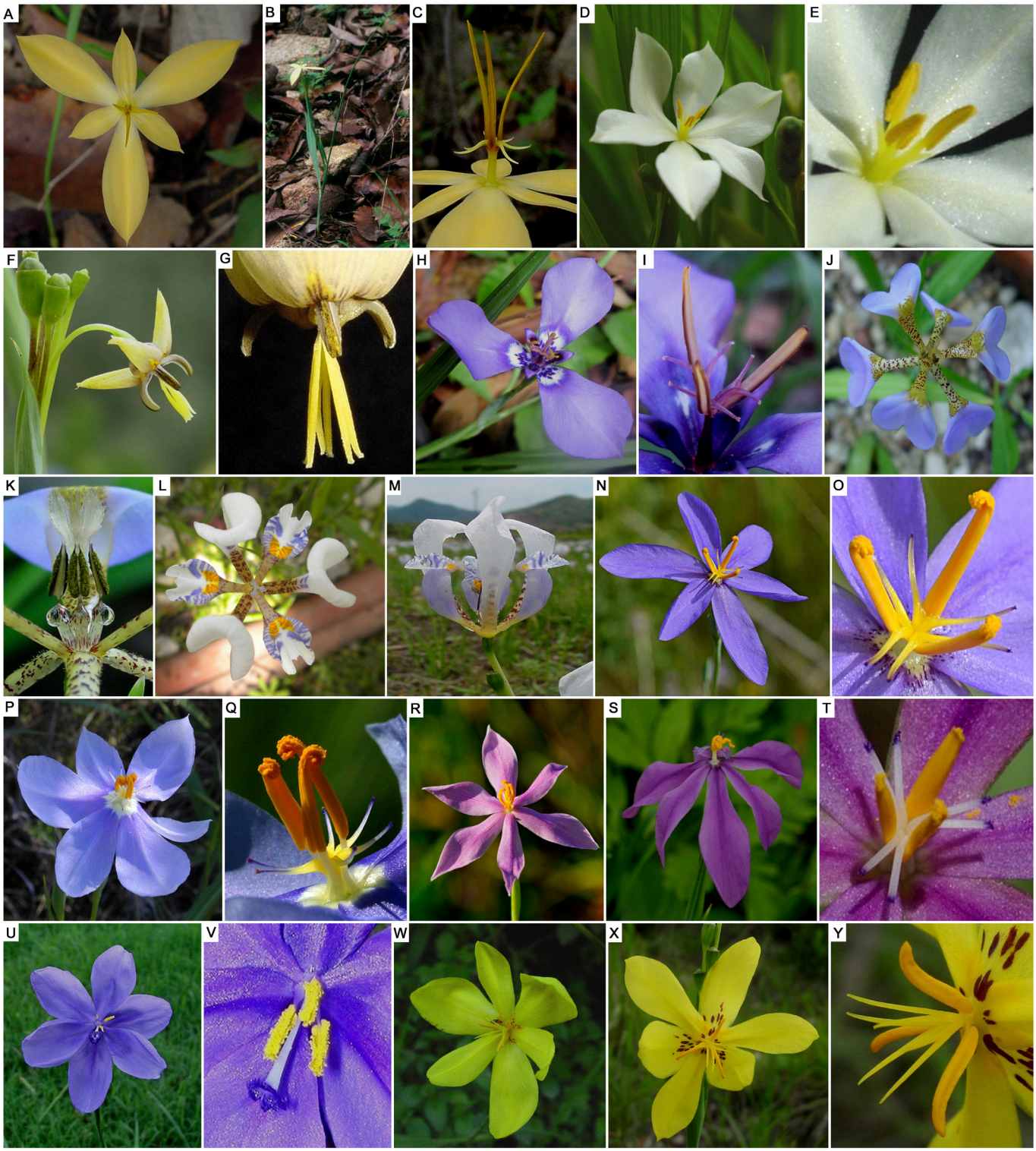

Figure 3. Morphological and color variability in flowers of Tigridieae. **A-C)** *Colima tuitensis*, **D-E)** *Eleutherine latifolia*, **F-G)** *Fosteria oaxacana*, **H-I)** *Herbertia lahue* ssp. *caerulea*, **J-K)** *Larentia mexicana*, **L-M)** *L. rosei*, **N-O)** *Nemastylis floridana*, **P-Q)** *N. geminiflora*, **R)** *N. nuttallii*, **S-T)** *N. tenuis*, **U-V)** *Salpingostylis coelestina*, **W)** *Sessilanthera citrina*, **X-Y)** *S. heliantha*. Photographs of Aarón Rodríguez (C-G, J-K, M, S-T), Guadalupe Munguía Lino (H-I, X-Y), Joseph A. Marcus (P), Munguía-Lino *et al*. 2015a (J, L, W), Randy Heisch (Q), Rodney Barton (U-V), Rodríguez and Ortiz-Catedral 2003a (A-B), Vic Prislipsky (R) and Wayne Matchett (N-O).

interior tepals and the trichomes secrete nectar. Nectaries can be exposed on the surface of the tepal but, in various species of *Tigridia*, the nectary is protected by a fold of the tepal. The color of the nectary has been recorded as achromatic, white or yellow. *Alophia* (Figures 2C-M) and *Herbertia* (Figures 3H-I) present nectaries with trichomes that secrete oil on the exterior and interior tepals. *Ainea* (Figures 2A-B), *Nemastylis* (Figures 3N-T), *Eleutherine* (Figures 3D-E), *Cardiostigma* (Figures 2N-T), *Cipura* (Figures 2U-V), *Colima* (Figures 2Y-Z and 3A-C) and *Cobana* (Figures 2W-X) do not have nectaries.

The stamens are also very variable. There are differences in length, degree of fusion and strength of the filaments. The anthers may be free or connate varying in size, shape and color. Their orientation, relative to the vertical line of the filaments, can be erect, ascendant, divaricate or reclinate. The dehiscence may be poricidal or loculicidal. In some species, the basal or distal half is sterile. The degree of maturity determines their shapes. In *Nemastylis* (Figures 3N-T), the anthers are erect prior to anthesis, after which they coil up.

One characteristic of Tigridieae is the variability exhibited by the style and its branches. The style is always divided into three branches. However, in some species, such as *Cipura campanulata* Ravenna (Figures 2U-V), *Salpingostylis coelestina* (Figures 3U-V) and *Cardisotigma mexicana* (R.C. Foster) Ravenna (Figures 2S-T), each branch is reduced to a stigmatic surface. The branches can be simple or each branch is divided into two arms, in which case, the style has six arms. It is common to observe a mucro at the base of the arms. When the branches are divided, they are filiform or flabelliform.

The stamens and style of the Tigridieae flowers form a complex and specialized structure (Goldblatt & Henrich 1991). The filaments can form a tube through which the style passes. The branches of the style are opposite to the anthers and, in the cases of bifurcate styles, each arm alternates with the anthers. Thus, between two anthers there are two arms of different branches. Another specialization is seen in *Larentia* (Figures 3J-M), where the apex of the anthers adheres to the abaxial part of the branch of the style, just below the stigma. Careful observation of these floral characteristics of Tigridieae facilitates their correct identification.

Reproductive biology. Tigridieae species propagate by bulb and by seed. Their fruit is a capsule with many seeds that fall to the ground, germinate and form a bulbel which, after two years, is a bulb ready to flower. Sexual reproduction is the most common form and the most effective manner in which to increase populations (Molseed 1970, Borys *et al*. 2000, Vázquez-García 2011). Asexual propagation is rare in wild populations. In contrast, in species used in ornamental horticulture, such as *Tigridia pavonia* and *Eleutherine bulbosa*, propagation by bulb is usual. *Tigridia pugana* Aarón Rodr. & Ortiz-Cat., develops bulbils in the axils of the cauline leaves (Rodríguez & Ortiz-Catedral 2006). This characteristic has been observed rarely in populations of *T. pavonia* and *T. ehrenbergii* (Schltdl.) Molseed ssp. *flaviglandifera* Cruden.

The life cycle of Tigridieae has been little studied. In the greenhouse, a period of between 180 and 220 days is estimated from germination to seed formation (Vázquez-García 2011). In the field, the relationship between vegetative growth and the development of the floral stem is of two types. In some species, development of the floral scape and flowering occurs eight days after the start of the rainy season (Molseed 1970). In contrast, other species develop basal leaves over four to six weeks, and then flowering occurs. In this way, flowering in species of Tigridieae is determined by the cycle of rains in each region. Anthesis is very ephemeral and lasts only three to four hours. Some species of *Tigridia* are allogamous and self-pollination is rare (Molseed 1970). Floral variability is proof of the interaction with pollinators. While studies of effective Tigridieae pollinators are rare, floral visitors have been observed in the field depending on flower color. For example, blue flowers are visited by bumblebees, yellow flowers by bees, dark flowers with a chlorine smell by flies, red flowers by hummingbirds and white flowers by moths. Seed dispersion is by gravity and, in cases such as *T. augusta* and *T. mexicana* ssp. *mexicana*, it is very probable that it also takes place by the movement of water. In *Nemastylis*, dispersion is by wind (Goldblatt & Manning 2008). Seeds of *Nemastylis tenuis* measure less than 1 mm (Figure 1 C').

Phylogeny. Tigridieae is a monophyletic group and is related to the tribe Trimezieae. Within Tigridieae, the infrageneric relationships are unresolved and have been studied based on different evidence (Molseed 1970, Rudall 1991, Rudall & Wheeler 1988, Goldblatt 1982, Williams *et al*.

Figure 4. Morphological and color variability in flowers of Tigridieae. **A-C)** *Sessilanthera latifolia*, **D)** *Tigridia alpestris* ssp. *alpestris*, **E)** *T. alpestris* ssp. *obtusa*, **F)** *T. amatlanensis*, **G-H)** *T. augusta*, **I)** *T. bicolor*, **J)** *T. catarinensis*, **K-L)** *T. chiapensis*, **M)** *T. chrysantha*, **N)** *T. duguesii*, **O-P)** *T. durangense*, **Q)** *T. ehrenbergii* ssp. *ehrenbergii*, **R)** *T. ehrenbergii* ssp. *flaviglandifera*, **S)** *T. estelae*, **T)** *T. flammea*, **U-V)** *T. galanthoides*, **W-X)** *T. gracielae*, **Y)** *T. hallbergii* ssp. *hallbergii*. Photographs of Aarón Rodríguez (D-F, H, N, Q, S-V, X), Guadalupe Munguía Lino (A-C, G, K, L, P, R, W-X), Luis Miguel Vázquez García (J), Munguía-Lino *et al*. 2015a (I, O, T) and Virginia Ramírez Cruz (M).

Figure 5. Morphological and color variability in flowers of Tigridieae. **A)** *Tigridia hallbergii* ssp. *lloydii*, **B)** *T. hintonii*, **C-D)** *T. huajuapanensis*, **E)** *T. illecebrosa*, **F)** *T. immaculata*, **G)** *T. inusitata*, **H)** *T. mariaetrinitatis*, **I-J)** *T. martinezii*, **K-L)** *T. matudae*, **M-N)** *T. meleagris*, **O)** *T. mexicana* ssp. *lilacina*, **P)** *T. mexicana* ssp. *mexicana*, **Q)** *T. mexicana* ssp. *passiflora*, **R)** *T. molseediana*, **S)** *T. mortonii*, **T)** *T. multiflora*, **U)** *T. orthantha*, **V-Y)** *T. pavonia*. Photographs of Aarón Rodríguez (C-E, H, K, N-O, V, X), Guadalupe Munguía Lino (I-J, L-M, R, W, Y), Munguía-Lino *et al*. 2015a (P), Munguía-Lino *et al*. 2015b (B, Q, S), Luis Miguel Vázquez García (A, G, U) and Virginia Ramírez Cruz (F).

Figure 6. Morphological and color variability in flowers of Tigridieae. **A)** *Tigridia potosina*, **B-C)** *T. pugana*, **D-E)** *T. pulchella*, **F)** *T. rzedowskiana*, **G-H)** *T. seleriana*, **I)** *T. suarezii*, **J)** *T. tepoxtlana*, **K-L)** *T. vanhouttei* ssp. *roldanii*, **M-N)** *T. vanhouttei* ssp. *vanhouttei*, **O-P)** *T. venusta*. Photographs of Aarón Rodríguez (B-F, J, L-M), Guadalupe Munguía Lino (A, G-H, L, N-O) and Munguía-Lino *et al*. 2015a, (I).

1986, Goldblatt *et al*. 2008). Recently, Tigridieae was divided into clades A and B (Chauveau *et al*. 2012). Clade A includes *Ainea*, *Calydorea* Herb., *Catila* Ravenna, *Cipura*, *Cypella* Herb., *Herbertia*, *Kelissa* Ravenna, *Larentia*, *Nemastylis* and *Onira* Ravenna. It diversified in South America but *Cipura* and *Larentia* are represented in Mexico. *Ainea conzattii* is endemic to Oaxaca, Mexico. *Nemastylis tenuis* has a wide geographic distribution from New Mexico, USA, to Guatemala. On the other hand, *N. geminiflora*, *N. floridana* and *N. nuttallii* grow in Southern USA. In contrast, clade B contains *Alophia*, *Cardiostigma*, *Cardenanthus* R.C. Foster, *Cobana*, *Colima*, *Eleutherine*, *Ennealophus* N.E. Br., *Fosteria*, *Gelasine* Herb., *Hesperoxiphion* Baker, *Mastigostyla* I.M. Johnst., *Phalocallis* Herb., *Sessilanthera* and *Tigridia* (Chauveau *et al*. 2012, Munguía *et al*. 2016). Diversification of clade B occurred in Mexico; however, *Cardenanthus*, *Ennealophus*, *Gelasine*, *Hesperoxiphion*, *Mastigostyla* and *Phalocallis* are presently exclusive to South America. The results of Chauveau *et al*. (2012) and Goldblatt *et al*. (2008) suggest the inclusion of *Cardiostigma*, *Colima*, *Fosteria*, *Rigidella* and *Sessilanthera* within *Tigridia*. However, the cladograms are not well resolved and their supports are low (Goldblatt 1990, Rodríguez & Sytsma 2006, Goldblatt *et al*. 2008, Chauveau *et al*. 2012, Munguía-Lino *et al*. 2015a). Likewise, important species of the genera *Salpingostylis*, *Herbertia* and *Nemastylis* have not been included. At present, we refer to these as different genera.

Biogeography. Tigridieae is an American group extending from -31° S in Argentina in the Pampeña province, on the Atlantic slope and -25° S in Chile in the Atacama province on the Pacific slope to 38° N in the USA in the Eastern Forest province and 30° N in Mexico in the Sierra

Table 1. Diversity and distribution of Tigridieae in North America. Modified from Munguía-Lino *et al.* (2016). Abbreviations of the Mexican states are those of INEGI (2015) and those of the US states are taken from USGS (2015). *Species known from its type locality, **species known from one or two municipalities, ***species known from one state, ****species with several populations but reduced to a small area, *****species widely distributed with small populations.

Taxa	Distribution
Ainea conzattii (R.C. Foster) Ravenna****	Mexico (Oax)
Alophia drummondii (Graham) R.C. Foster*****	USA (TX), Mexico (Chis, Oax, Qro, SLP, Tab, Tamps, Ver)
Alophia intermedia (Ravena) Goldblatt****	Mexico (Nay, Sin)
Alophia silvestris (Loes.) Goldblatt*****	Belize, Costa Rica, Guatemala, Honduras, Mexico (Camp, Chis, Tab, Ver, Yuc), Nicaragua
Alophia veracruzana Goldblatt & T.M. Howard***	Mexico (Ver)
Cardiostigma hintonii (R.C. Foster) Ravenna****	Mexico (Jal, Mich)
Cardiostigma longispatha (Herb.) Baker*****	Mexico (Dgo, Gro, Jal, Mex, Mich, Nay)
Cardiostigma mexicana (R.C. Foster) Ravenna (Goldblatt & Henrich) Ravenna****	Mexico (Mex, Mich)
Cipura campanulata Ravenna*****	Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico (Camp, Chis, Gro, Jal, Mex, Mich, Mor, Nay, Oax, Pue, QR, Sin, Tab, Tamps, Ver, Yuc), Nicaragua, Panama, Paraguay, Puerto Rico, Uruguay, Peru, Venezuela
Cobana guatemalensis (Standl.) Ravenna****	Guatemala, Honduras, Mexico (Chis)
Colima convoluta (Ravenna) Aarón Rodr. & Ortiz-Cat., ***	Mexico (Col)
Colima tuitensis Aarón Rodr. & Ortiz-Cat.*	Mexico (Jal)
Eleutherine latifolia (Standl. & L.O. Williams) Ravenna*****	Guatemala, Honduras, Mexico (Chis, Gto, Hgo, Mex, Nay, Oax, Pue, Qro, SLP, Sin, Tab, Tamps, Ver, Zac)
Fosteria oaxacana Molseed****	Mexico (Oax)
Herbertia lahue (Molina) Goldblatt ssp. *caerulea* (Herb.) Goldblatt*****	USA (FL, TX)
Larentia mexicana (C.V. Morton & R.C. Foster) Goldblatt****	Mexico (Gro, Jal, Mich)
Larentia rosei (R.C. Foster) Ravenna****	Mexico (Nay, Sin)
Nemastylis floridana Small***	USA (FL)
Nemastylis geminiflora Nutt*****	USA (AL, AR, KS, LA, MS, MO, OK, TX)
Nemastylis nuttallii Pickering ex R.C. Foster***	USA (MO)
Nemastylis tenuis Baker *****	USA (AZ), Guatemala, Honduras, Mexico (Ags, Chih, Coah, DF, Dgo, Gro, Gto, Hgo, Jal, Mex, Mich, Mor, Nay, NL, Oax, Pue, Qro, SLP, Sin, Son, Ver, Zac)
Salpingostylis coelestina (W. Bartram) Small***	USA (FL)
Sessilanthera citrina Cruden****	Mexico (Gro)
Sessilanthera heliantha (Ravenna) Cruden****	Mexico (Gro, Oax, Pue)
Sessilanthera latifolia (Weath.) Molseed & Cruden****	Mexico (Gro, Mex, Mor, Pue)
Tigridia alpestris ssp. *alpestris* Molseed****	Mexico (Hgo, Mex)
Tigridia alpestris ssp. *obtusa* Molseed****	Mexico (Mex, Mich)
Tigridia amatlanensis Aarón Rodr. & García-Mend.*	Mexico (Oax)
Tigridia augusta Drapiez*****	Mexico (Jal, Mex, Mich, Pue, Zac)
Tigridia bicolor Molseed***	Mexico (Oax)
Tigridia catarinensis Cruden**	Mexico (SLP)
Tigridia chiapensis Molseed ex Cruden***	Mexico (Chis)
Tigridia chrysantha Cruden & S.J. Walker ex McVaugh**	Mexico (Jal)
Tigridia dugesii S. Watson****	Mexico (Dgo, Gto, Jal, Nay, Zac)
Tigridia durangense Molseed ex Cruden****	Mexico (Dgo, Mich)
Tigridia ehrenbergii ssp. *ehrenbergii* (Schltdl.) Molseed*****	Mexico (Gto, Gro, Hgo, Jal, Mex, Mich, Mor, Oax, Pue, Tlax, Ver)

Table 1. Continuation.

Taxa	Distribution
Tigridia ehrenbergii ssp. *flaviglandifera* Cruden****	Mexico (Hgo, Qro, SLP)
Tigridia estelae López-Ferr. & Espejo**	Mexico (Dgo)
Tigridia flammea (Lindl.) Ravenna**	Mexico (Mich)
Tigridia galanthoides Molseed****	Mexico (Gro, Oax, Ver)
Tigridia gracielae Aarón Rodr. & Ortiz-Cat.**	Mexico (Mex)
Tigridia hallbergii ssp. *hallbergii* Molseed*****	Guatemala, Mexico (Chis, Gro, Oax, Pue)
Tigridia hallbergii ssp. *lloydii* Cruden**	Mexico (Mex)
Tigridia hintonii Molseed**	Mexico (Gro)
Tigridia huajuapanensis Molseed ex Cruden****	Mexico (Oax, Pue)
Tigridia illecebrosa Cruden****	Mexico (Oax, Pue)
Tigridia immaculata Herb. *****	Guatemala, Mexico (Chis, Oax)
Tigridia inusitata (Cruden) Ravenna**	Mexico (Gro)
Tigridia mariaetrinitatis Espejo & López-Ferr.*	Mexico (Oax)
Tigridia martinezii Calderón**	Mexico (Hgo)
Tigridia matudae Molseed**	Mexico (Mex, Mor)
Tigridia meleagris G. Nicholson*****	Guatemala, Mexico (Col, Dgo, Gro, Jal, Mex, Mich, Mor, Nay, Pue, Zac)
Tigridia mexicana ssp. *lilacina* Molseed***	Mexico (Jal)
Tigridia mexicana ssp. *mexicana* Molseed*****	Mexico (Mex)
Tigridia mexicana ssp. *passiflora* Molseed****	Mexico (Jal, Nay)
Tigridia molseediana Ravenna****	Guatemala, Mexico (Oax)
Tigridia mortonii Molseed**	Mexico (Mex)
Tigridia multiflora (Herb.) Ravenna****	Mexico (Ags, Chih, DF, Dgo, Gto, Hgo, Jal, Mex, Mich, Mor, NL, Oax, Pue, Qro, SLP, Tamps, Zac), Venezuela
Tigridia orthantha (Lem.) Ravenna*****	Guatemala, Mexico (Chis, Oax, Ver)
Tigridia pavonia (L. f.) DC. *****	Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico (Chis, Chih, DF, Dgo, Gto, Gro, Hgo, Jal, Mex, Mich, Mor, Nay, NL, Oax, Pue, Qro, SLP, Sin, Son, Tamps, Tlax, Ver, Zac), Peru
Tigridia potosina López-Ferr. & Espejo*	Mexico (SLP)
Tigridia pugana Aarón Rodr. & Ortiz-Cat.**	Mexico (Jal)
Tigridia pulchella B.L. Rob. ****	Mexico (Jal, Mich)
Tigridia purpusii Molseed*	Mexico (Pue)
Tigridia rzedowskiana Aarón Rodr. & Ortiz-Cat.**	Mexico (Qro, Ver)
Tigridia seleriana (Loes.) Ravenna****	Guatemala, Mexico (Oax)
Tigridia suarezii Aarón Rodr. & Ortiz-Cat. ***	Mexico (Jal)
Tigridia tepoxtlana Ravenna***	Mexico (Mor)
Tigridia vanhouttei ssp. *roldanii* Molseed****	Mexico (Hgo, Pue, Tlax)
Tigridia vanhouttei ssp. *vanhouttei* (Baker) Espejo & López-Ferr. *****	Mexico (DF, Hgo, Mex, Mor, Qro, SLP, Tlax, Ver)
Tigridia venusta Cruden**	Mexico (Mich)

Madre Occidental. *Nemastylis geminiflora* has the most Northern distribution, while *Cypella herbertii* Herb., and *Gelasine elongata* (Graham) Ravenna grow in the most southern regions. *Cipura paludosa* Aubl., *C. campanulata*, *Eleutherine latifolia* (Standl. & L.O. Williams) Ravenna, *E. bulbosa* and *Tigridia pavonia* are widely distributed (Munguía-Lino *et al*. 2015a). *Tigridia pavonia* and *E. bulbosa* are cultivated as ornamental plants and have become naturalized in other parts of the world (Rodríguez & Ortiz-Catedral 2001, Vázquez-García 2011).

Tigridieae diversified in the transition zones. In North America, its areas of endemism are located in the Mexican Transition Zone; this component corresponds to the biogeographic provinces of Chiapas Highlands, the Transmexican Volcanic Belt, Sierra Madre Occidental, Sierra Madre Oriental and Sierra Madre del Sur. These zones have allowed geographic isolation to occur, favoring the speciation of Tigridieae, and have functioned as biological corridors for its dis-

Figure 7. Dissections of Tigridieae. **A-E)** materials, **F)** dissection, **G)** dried, **H-I)** herbarium specimens. Photographs of Guadalupe Munguía Lino (A-I).

persion (Munguía-Lino *et al*. 2015a). Munguía-Lino *et al*. (2016), using Analysis of Endemism and Parsimony of Endemisms, identified five biotic components for Tigridieae: 1) Northern Mexico, 2) Western Mexico, 3) Central Mexico, 4) Southern Mexico and 5) Central/southern Mexico. Of these areas, four are related to the Transmexican Volcanic Belt, which began to form approximately 13 million years ago during the Late Miocene (Ferrari *et al*. 1999). Since then, its transformation has created topographic irregularities with climatic variations that have favored biological diversification. Tigridieae is one example; the tribe had its greatest distribution in the Oligocene and the Miocene 15 Mya, an event that coincides with the formation of the Transmexican Volcanic Belt (Goldblatt *et al*. 2008, Munguía-Lino *et al*. 2015a).

In North America, the number of endemisms of Tigridieae is high. Sixty-one taxa are endemic and, of these, 54 are exclusive to Mexico. Oaxaca is the state with the highest number of endemic taxa (6), followed by Jalisco (5) and Mexico (5). Furthermore, there are microendemic species known only in their type locality. These include *Colima tuitensis* Aarón Rodr. & Ortiz-

Cat., *Tigridia amatlanensis* Aarón Rodr. & García-Mend., *T. mariaetrinitatis* Espejo & López-Ferr., *T. potosina* López-Ferr. & Espejo and *T. purpusii* Molseed. Species such as *T. catarinensis* Cruden, *T. chrysantha* Cruden & S.J. Walker ex McVaugh, *T. estelae* López-Ferr. & Espejo, *T. flammea* (Lindl.) Ravenna, *T. gracielae* Aarón Rodr. & Ortiz-Cat., *T. hintonii* Molseed, *T. inusitata* (Cruden) Ravenna, *T. martinezii* Calderón, *T. matudae* Molseed, *T. mortonii* Molseed, *T. pugana*, *T. rzedowskiana* Aarón Rodr. & Ortiz-Cat. and *T. venusta* Cruden are only known in one or two municipalities. Furthermore, *Alophia veracruzana* Goldblatt & T.M. Howard, *Colima convoluta* (Ravenna) Aarón Rodr. & Ortiz-Cat., *Salpingostylis coelestina*, *Nemastylis floridana*, *N. nuttallii*, *T. bicolor* Molseed, *T. chiapensis* Molseed ex Cruden, *T. suarezii* Aarón Rodr. & Ortiz-Cat., and *T. tepoxtlana* Ravenna are examples of species endemic to one state (Table 1). Regarding the other species, several populations are recorded but these are restricted to a reduced area. In this condition are found *Fosteria oaxacana* Molseed, *Larentia mexicana* (C.V.Morton & R.C.Foster) Goldblatt, *L. rosei* (R.C. Foster) Ravenna, *Sessilanthera citrina* Cruden, *S. heliantha* (Ravenna) Cruden, *S. latifolia* (Wheath.) Molseed ex Cruden, *T. dugesii* S. Watson, *T. durangense* Molseed, *T. galanthoides* Molseed, *T. huajuapanensis* Molseed ex Cruden, *T. molseediana* Ravenna, *T. pulchella* B.L. Rob. and *T. seleriana* (Loes.) Ravenna. Finally, the remaining species have wide geographic distributions but few populations. Fortunately, the number of individuals in these populations is generally high. Species in this category include *Tigridia augusta*, *T. eherenbergii* ssp. *ehrenbergii*, *T. hallbergii* Molseed ssp. *hallbergii*, *T. meleagris* G. Nicholson, *T. mexicana* Molseed ssp. *mexicana*, *T. orthantha* (Lem.) Ravenna and *T. vanhouttei* (Baker) Espejo & López-Ferr. ssp. *vanhouttei* (Table 1).

Fresh dissections of Tigridieae flowers. Tigridieae flowers are very ephemeral, which explains why they are known as *flor de un rato* or *de un día* (flower of a short time or of a day). The time of flowering is variable. On sunny days, flowers of most of the species open in the early hours of the morning or a little later in the day if it is cloudy. In *Cipura campanulata* (Figures 2U-V), the flowers open between the seven and nine in the morning, while *Eleutherine latifolia* (Figures 3D-E) produces flowers opening almost at dusk. In both cases, the pollinators are moths. Anthesis of the flowers of *Nemastylis tenuis* (Figures 3S-T), *Tigridia dugesii* (Figure 4N) and *T. catarinensis* (Figure 4J) occurs after 3:00 pm. In all cases, anthesis lasts for approximately three hours. Afterwards, the tepals close, tangling together eventually forming a fluid mass. The only exception is *Tigridia pavonia* (Figures 5V-Y), whose flowers remain open for 10 to 14 hours.

In order to conserve and appreciate the shape and color of the Tigridieae tepals, fresh dissection is recommended. For this, transparent self-adhesive paper is used, as well as white absorbent paper (disposable tissues, toilet paper or bond paper), re-sealable bags and silica gel (Figures 7A-E). The exterior and interior tepals, style, stigma and ovary are dissected separately. Subsequently, each floral piece is accommodated in a transparent self-adhesive paper of 10 x 10 cm, taking care not to mistreat the structures. A sheet of white absorbent paper is then placed on the self-adhesive paper with the adhered floral structures (Figure 7F). The dissection is placed in a re-sealable bag with 250 g of silica gel. Air must be eliminated from the bag, and then it is sealed and allowed to dry for 24 hours (Figure 7G). The vegetative parts are dried by conventional methods (Lot & Chiang 1986) and finally the floral dissection is annexed to the mounted herbarium specimen (Figures 7H-I).

Description of the tribe Tigridieae

Tigridieae Kitt., Achilles Richard's Grundriss der Botanik und der Pflanzenphysiologie. 1840.
Perennial herbaceous plants; **bulbs** ovoid, obovoid, ovate to oblong, tunicated, papery tunics, brown, dark-brown or reddish; **leaves** unifacial, plicate or foliate, ensiform, lanceolate or linear, glabrous, entire or with rotundate teeth just perceptible to touch, basal and cauline; **floral stem** glabrous or scabridulous, simple or branched; **inflorescence** a rhipidium, covered by 2 or 3 spathaceous bracts, lanceolate; **flowers** pedicellate or sessile, subtended by membranaceous and hyaline bract, trimerous; **tepals** free, sometimes differentiated into distal and basal parts, known as limb and claw, respectively; exterior and interior tepals very variable in form, color and size, maculate, striate or variegated; **nectaries** when present on the adaxial surface of the interior or exterior tepals, or both, formed of oil-secreting (elaiophores) or nectar-secreting trichomes;

ovary inferior, tricarpellar and trilocular; **stamens** 3, opposite to the exterior tepals, alternate to the interior tepals; **filaments** free and connate forming a column; **anthers** basifixed, extrorse, with porocidal or longitudinal dehiscence; **pollen grains** monosulcate, disulcate, tricotomosulcate or zonasulcate; **style** terminal, 3-branched; **branches** of the style entire, bifid or bifurcate, in some cases with a small mucro on the sinus, filiform, lobate, petaloid or cristate; **fruit** a capsule, loculicidal, with dehiscence by three apical or lateral sutures; **seeds** numerous per locule, globose, semiglobose, piriform, dark brown to reddish brown; 2n = 2x = 14, 2n = 4x = 28.

Key for the identification of North American Tigridieae

1. Rhipidia fasciculate, 1-6, sessile, 1 flower per rhipidium; flowers sessile; tepals white; filaments free; style branches very reduced, difficult to distinguish from the style, sometimes represented by small lobules; dehiscence of the capsules by three sutures ……..…. *Cipura*
1. Rhipidia solitary, sessile o pedunculate, with 2 to several flowers; flowers pedunculate; tepals of various colors; filaments free or connate; style branches conspicuous, entire, bifurcate, bifid, filiform or variable; capsules dehiscent by three apical sutures
2. Filaments free
3. Style branches bifurcate, yellow
4. Interior and exterior tepals of equal size, blue .....…..…..…….....…... *Cardiostigma*
4. Interior tepals very reduced in size, white ……..…….....……... *Ainea*
3. Style branches entire, white or blue
5. Style branches conspicuous
6. Style branches flabelliform; apex of each anther adpressed to the style branch below the stigma; stigma petaloid or cristate; bulbs with brown tunics …… .....…..... *Larentia*
6. Style branches filiform; apex of each anther not adpressed to the style branch below the stigma; stigma subulate; bulbs with reddish tunics .....… *Eleutherine*
5. Style branches inconspicuous, reduced to a stigmatic surface
7. Style branches white; plants of Mexico …….....…… *Cardiostigma*
7. Style branches blue; plants of Florida, USA …….....…..... *Salpingostylis*
2. Filaments connate
8. Style branches entire; anthers with poricidal dehiscence ……..…….. *Cobana*
8. Style branches bifurcate; anthers with poricidal or longitudinal dehiscence
9. Filaments less than 3 mm long; anthers with poricidal dehiscence ..... *Sessilanthera*
9. Filaments more than 3 mm long; anthers with longitudinal dehiscence
10. Nectaries absent on the adaxial surface of the tepals
11. Tepals blue or white …..…..…….…..…..…….....…. *Nemastylis*
11. Tepals yellow …..……..……..…..…..…….....……..……..… *Colima*
10. Nectaries present on the adaxial surface of the interior or exterior tepals, or both
12. Interior and exterior tepals with nectaries formed by oil-secreting trichomes (elaiophores)
13. Exterior and interior tepals equal or subequal in size, anthers with a wide connective, pandurate …..……..…..……..……..……..…… *Alophia*
13. Exterior tepals larger than interior; anthers not pandurate ....….....… *Herbertia*
12. Interior tepals with nectaries formed by nectar-secreting trichomes
14. Style branches erect, papillose and stigmatic …….....…..…..… *Fosteria*
14. Style branches ascendant, divaricate or reclinate, glabrous, stigma apical and subulate ……..…..…….…..……..……..…..… *Tigridia*

Clave para la identificación de los géneros de Tigridieae en Norte América

1. Ripidios fasciculados, 1-6, sésiles, 1 flor por ripidio; flores sésiles; tépalos blancos; filamentos libres; ramas del estilo muy reducidas, difícilmente distinguibles del estilo, a veces representadas por pequeños lóbulos; dehiscencia de las cápsulas por tres suturas ..... *Cipura*
1. Ripidios solitarios, sésiles o pedunculados, con 2 a varias flores; flores pedunculadas; tépalos de varios colores; filamentos libres o connados; ramas del estilo conspicuas, enteras, bifurcadas, bífidas, filiformes o variadamente elaboradas; dehiscencia de las cápsulas por tres suturas apicales

2. Filamentos libres
3. Ramas del estilo bifurcadas, amarillas
4. Tépalos interiores y exteriores de igual tamaño, azules ….....….....….... *Cardiostigma*
4. Tépalos interiores muy reducidos en tamaño, blancos ……....……..... *Ainea*
3. Ramas del estilo enteras, blancas o azules
5. Ramas del estilo conspicuas
6. Ramas del estilo flabeliformes; ápice de cada antera adpreso a la rama del estilo por debajo del estigma; estigma petaloide o crestado; bulbos con túnicas pardas ..... *Larentia*
6. Ramas del estilo filiformes; ápice de cada antera no adpreso a la rama del estilo por debajo del estigma; estigma subulado; bulbos con túnicas rojizas …..... *Eleutherine*
5. Ramas del estilo inconspicuas, reducidas a una superficie estigmática
7. Ramas del estilo blancas; plantas de México ….....…… .. *Cardiostigma*
7. Ramas del estilo azules; plantas de Florida, EUA ……..... *Salpingostylis*
2. Filamentos connados
8. Ramas del estilo enteras; anteras con dehiscencia poricida …….....…….. *Cobana*
8. Ramas del estilo bifurcadas; anteras con dehiscencia poricida o longitudinal
9. Filamentos reducidos, de menos de 3 mm de long.; anteras con dehiscencia poricida…….....…….....…... *Sessilanthera*
9. Filamentos de más de 3 mm de long.; anteras con dehiscencia longitudinal
10. Nectarios ausentes en la superficie adaxial de los tépalos
11. Tépalos azules o blancos ….…….....……..…..…. ...*Nemastylis*
11. Tépalos amarillos ……....……..…..…..…….....…… *Colima*
10. Nectarios presentes en la superficie adaxial de los tépalos interiores, exteriores o ambos
12. Tépalos interiores y exteriores con nectarios formados de tricomas secretores de aceite (elaioforos)
13. Tépalos exteriores e interiores iguales o subiguales en tamaño; anteras con un amplio conectivo, panduradas …..……..……...……..…...…… *Alophia*
13. Tépalos exteriores más grandes que los interiores; anteras no panduradas …… ..……...…….…. *Herbertia*
12. Tépalos interiores con nectarios formados de tricomas secretores de néctar
14. Ramas del estilo erectas, papilosas y estigmáticas ….....…...…… *Fosteria*
14. Ramas del estilo ascendentes, divaricadas o reclinadas, glabras, estigma apical y subulado ……..……...…….....……...… *Tigridia*

Key for the identification of species of Tigridieae in North America

1. Rhipidia fasciculate, 1-6, sessile, 1 flower per rhipidium; flowers sessile; tepals white; filaments free; style branches very reduced, difficult to distinguish from the style, sometimes represented by small lobules; dehiscence of the capsules by three sutures; plants of wide distribution in Mexico and South America; at elevations of 0-2,400 m…….....*Cipura campanulata* (Figures 2U-V)
1. Rhipidia solitary, sessile pedunculate, with 2 to several flowers; flowers pedunculate; tepals of various colors; filaments free or connate; style branches conspicuous, entire, bifurcate, bifid, filiform or variably presented; dehiscence of the capsules by three apical sutures
2. Filaments free
3. Style branches bifurcate, yellow
4. Interior and exterior tepals subequal in size, blue; arms filiform, retuse; plants of Jalisco and Michoacán; elevations of 1,300-2,000 m …… *Cardiostigma hintonii* (Figures 2N-O)
4. Interior tepals very reduced in size, white; interiors with two yellow spots; plants of Oaxaca; elevations of 1,800-2,900 m..……...……....…..... *Ainea conzattii* (Figures 2A-B)
3. Style branches entire, white or blue
5. Style branches conspicuous
6. Style branches flabelliform; apex of each anther adpressed to the style branch below the stigma; stigma petaloid or cristate; bulbs with brown tunics
7. Style branches 11-12 mm long, including the stigmatic crests; column below the branches 6-7 mm long; anthers 3.5-4 mm long; filaments 4.5-5 mm long; tepals with one narrow

claw 1 cm long, well defined; interior tepals puberulent at the base of the limb, with glandular hairs, from 0.1 to 0.3 mm long; plants of Guerrero, Jalisco and Michoacán; elevations of 0-1,200 m ……..…….. ……..…….. *Larentia mexicana* (Figures 3J-K)

7. Style branches of 15 to 19 mm long, including the stigmatic crests; column below the branches 10 to 12 mm long; anthers 5.5-6(-7) mm long; filaments 6-7 mm long, segments of the perianth clavate, obovate-cuneate; base of the limb without glandular hairs; plants of Nayarit and Sinaloa; elevations of 0-500 m ……..……...… *Larentia rosei* (Figures 3L-M)

6. Style branches filiform; apex of each branch not adpressed to the style branch below the stigma; stigma subulate; bulbs with reddish tunics; plants of wide distribution in Mexico, Guatemala and Honduras; elevations of 0-2,400 m ……... *Eleutherine latifolia* (Figures 3D-E)

5. Style branches inconspicuous, lobate or reduced to a stigmatic surface

8. Style branches white; plants of Mexico

9. Leaf cauline, wrapping and exceeding the rhipidium; inflorescence sessile; style branches lobate; stigma cuneate, ciliate and puberulent; plants of Durango, Guerrero, Jalisco, Estado de México, Michoacán and Nayarit; elevations of 1,000-3,200 m..……...….. …...……...……...…….....*Cardiostigma longispatha* (Figures 2P-R)

9. Leaf cauline inserted at 2-7 cm below the rhipidium and exceeding it; inflorescence peduncle; style branches reduced to stigmatic surface; stigmas cuneate-reniform, puberulent; plants of Estado de México and Michoacán; elevations of 700-2,500 m …….…… …...……...……...……...…..*Cardiostigma mexicana* (Figures 2S-T)

8. Style branches blue; plants of Florida; elevations of 0-100 m…….....….. …...……...…..……..... *Salpingostylis coelestina* (Figures 3U-V)

2. Filaments connate

10. Style branches entire; anthers with poricidal dehiscence; tepals white, concolorous; plants of Chiapas, Guatemala and Honduras; elevations from 1,000-2,000 m……...…… ..... ……..……...… *Cobana guatemalensis* (Figures 2W-X)

10. Style branches bifurcate; anthers with poricidal or longitudinal dehiscence; tepals of different colors

11. Filaments less than 3 mm long; anther with poricidal dehiscence

12. Tepals white, with 2 yellow spots at the base of the interior tepal; plants of Guerrero, Estado de México, Morelos and Puebla; elevations of 800-2,200 m ……..…….....…….. ..……...……...… *Sessilanthera latifolia* (Figures 4A-C)

12. Tepals yellow, with spots of color purple at the base

13. Tepals yellow-lemon; purple spots within a yellow patch at the base of the interior tepals; inhabits in pine-oak forests; plants of Guerrero; elevations of 900-2,200 m ....……...……..... *Sessilanthera citrina* (Figure 3W)

13. Tepals bright-yellow, with purple spots at the base of the interior and exterior tepals; inhabits tropical deciduous forest and oak forest; plants of Guerrero; elevations of 850-2,200 m..……...…….....…..…... *Sessilanthera heliantha* (Figures 3X-Y)

11. Filaments more than 3 mm long; anthers with longitudinal dehiscence

14. Nectaries absent on the adaxial surface of the tepals

15. Tepals blue or white

16. Cauline leaves well-developed, 5-11 mm wide; plants of Alabama, Arkansas, Kansas, Lousiana, Mississippi, Missouri, Oklahoma and Texas; elevations of 0-2,400 m ..... ……..…….....…..……...……*Nemastylis geminiflora* (Figures 3P-Q)

16. Cauline leaves reduced, if developed, 1-4 mm wide

17. Floral stem branched; plants autumn flowering; plants of Florida; elevations of 0-50 m ……..... *Nemastylis floridana* (Figures 3N-O)

17. Floral stem not branched; plants flowering in spring and summer

18. Style arms 2 mm long, shorter than the anthers; plants with flowering in spring; plants of Missouri; elevations of 200-500 m……..…… *Nemastylis nutallii* (Figure 3R)

18. Style arms 4 mm long, longer than the anthers; plants flowering in the summer; plants of wide distribution in Mexico, Texas, Arizona, Guatemala and Honduras; elevations of 50-3,000 m ……...……..……...… *Nemastylis tenuis* (Figures 3S-T)

15. Tepals yellow

19. Floral stem, peduncle, pedicels and fruits wingless; tepals soft yellow; plants of Jalisco; elevations of 400-500 m……..... *Colima tuitensis* (Figures 3A-C)
19. Floral stem, peduncle, pedicels and fruits not alate; tepals bright yellow; plants of Colima; elevations of 400-800 m…….....……*Colima convoluta* (Figures 2Y-Z)
14. Nectaries present on the adaxial surface of the interior or exterior tepals, or both
20. Interior and exterior tepals with nectaries formed by oil-secreting trichomes (elaio-phores)
21. Exterior and interior tepals equal or subequal in size; anthers with a wide connective, pandurate, erect
22. Anthers yellow; plants of Sinaloa and Nayarit; elevations of 0-500 m ....……..…..……..…..…… *Alophia intermedia* (Figures 2F-G)
22. Anthers purple; plants of the slope of the Gulf of Mexico
23. Interior tepals extended; plants of Campeche, Chiapas, Tabasco, Veracruz, Yucatán, Belize, Costa Rica, Guatemala, Honduras and Nicaragua; elevations of 0-500 m..... ……..... *Alophia silvestris* (Figures 2H-J)
23. Interior tepals geniculate
24. Basal leaves 1-2; interior tepals with a well defined claw; plants of Chiapas, Oaxaca, Querétaro, San Luis Potosí, Tabasco, Tamaulipas, Veracruz and of wide distribution in the USA; elevations of 0-900 m..... *Alophia drummondii* (Figures 2C-E)
24. Basal leaves 2-3; interior tepals without a well-defined claw; plants of Veracruz; elevations of 0-200 m …….....…..… *Alophia veracruzana* (Figures 2K-M)
21. Exterior tepals larger than the interior tepals; anthers not pandurate, ascendant; plants of Florida and Texas; elevations of 0-200 m ….....…….……..... ……...…..… *Herbertia lahue* ssp. *caerulea* (Figures 3H-I)
20. Exterior tepals without nectaries; interior tepals with nectaries formed from nectar-secreting trichomes
25. Style branches erect, papillose and stigmatic; plants of Oaxaca; elevations of 1,400-2,600 m….....…..……...…..…….. *Fosteria oaxacana* (Figures 3F-G)
25. Style branches ascendant, divaricate or reclinate, glabrous; stigma apical and subulate
26. Interior tepals with nectaries exposed
27. Tepals red, flowers pollinated by hummingbirds
28. Flowers erect or ascendant
29. Flowers erect; interior tepals exerted, of the same length as the staminal column; style arms without mucro; plants of Chiapas, Oaxaca, Veracruz y Guatemala; elevations of 1,000-3,200 m.…..……..… *Tigridia orthantha* (Figure 5U)
29. Flowers ascendant; interior tepals not exerted, less than staminal column; style arms with a small mucro; plants of Guerrero; elevations of 1,800-3,200 m..... ……..... *Tigridia inusitata* (Figure 5G)
28. Flowers nutant
30. Exterior tepals with purple spots; style arms with a mucro; plants of Michoacán; elevations of 1,900-2,400 m…….....……..…..… *Tigridia flammea* (Figure 4T)
30. Exterior tepals immaculate; style arms without mucro; plants of Chiapas, Oaxaca and Guatemala; elevations of 1,800-3,000 m.*Tigridia immaculata* (Figure 5F)
27. Tepals white, yellow, blue, purple, pink and yellowish-white; flowers pollinated by flies, bees and bumblebees
31. Flowers erect
32. Apex of the tepals cirrhous; flowers opening in the afternoon; plants of San Luis Potosí; elevations of 1,600-1,800 m..... *Tigridia catarinensis* (Figure 4J)
32. Apex of the tepals not cirrhous; flowers opening in the morning.
33. Flowers 8 cm in diameter; apex of the interior tepals attenuate; capsules globose; plants of Puebla; elevations of 1,700 m……..... *Tigridia purpusii*
33. Flowers 0.8-5 cm in diameter; apex of the interior tepals acuminate, acute, obtuse or retuse; capsules claviform to claviform-oblong
34. Tepals discolorous
35. Apex of the interior tepal very reduced

36. Tepals forming a yellow cup, with a white distal part; grows on cultivated land; plants of Oaxaca; elevations of 2,380-2,445 m ……..
……..……..……. *Tigridia mariaetrinitatis* (Figure 5H)
36. Tepals forming a white or purple cup
37. Tepals forming a white cup, maculate and urceolate; plants of Jalisco and Michoacán; elevations of 1,700-2,800 m.... *Tigridia pulchella* (Figures 6D-E)
37. Tepals forming a purple cup, maculate or striate, not urceolate
38. Exterior tepals apiculate; interior tepals sagitate; axil of the leaves cauline with bulbils; plants of Jalisco; elevations of 1,900-2,100 m…….....……
……*Tigridia pugana* (Figures 6B-C)
38. Exterior tepals emarginate; interior tepals circular; axil of the leaves cauline without bulbils; plants of Oaxaca; elevations of 1,800-2,600 m……...……
…….....…...……*Tigridia bicolor* (Figure 4I)
35. Apex of the interior tepal developed, conspicuous and retrorse
39. Diameter of the flower 5 cm; cup yellowish and maculate; plants of Querétaro and Veracruz; elevations of 1,000-2,600 m.……
……..… *Tigridia rzedowskiana* (Figure 6F)
39. Diameter of the flower less than 5 cm; cup white, maculate or striate
40. Cup striate
41. Interior tepal with a claw 5-6 mm long; plants of San Luis Potosí; elevations of 1,996-2,352 m…….....……..… *Tigridia potosina* (Figure 6A)
41. Interior tepal with a claw 2 mm long; plants of Jalisco; elevations of 2,100-2,800 m…..... *Tigridia suarezii* (Figure 6I)
40. Cup maculate
42. Plants of 30-60 cm; anthers sterile in the distal half, 12-13 mm long; staminal column 4-5 mm long; plants of Michoacán; elevations of 2,500-2,900 m…….....……..…… *Tigridia venusta* (Figures 6 O-P)
42. Plants of 40-45 cm; anthers fertile over the whole length, 6.5 mm long; staminal column 10 mm long; plants of Estado de México and Michoacán; elevations of 2,900-3,000 m.....….. *Tigridia gracielae* (Figures 4W-X)
34. Tepals concolorous or uniformly maculate, variegated or striate.
43. Apex of the interior tepal very reduced
44. Tepals forming an open cup; interior tepals reniform; staminal column exerted; plants of Oaxaca and Puebla; elevations of 1,500-2,100 m .....
.....……..……*Tigridia huajuapanensis* (Figures 5C-D)
44. Tepals forming a deep cup; interior tepals circular; staminal column not exerted; plants of Ciudad de México, Estado de México, Hidalgo, Morelos, Querétaro, San Luis Potosí, Tlaxcala and Veracruz; elevations of 2,200-2,900 m..….....*Tigridia vanhouttei* ssp. *vanhouttei* (Figures 6M-N)
43. Apex of the interior tepal well developed, conspicuous and retrorse
45. Tepals yellowish-white or bluish-purple light
46. Cup maculate; style arms white; plants of Hidalgo; elevations of 2,900-3,000 m…….....……*Tigridia martinezii* (Figures 5I-J)
46. Cup striate; style arms pink
47. Flowers 5.5-6.5 cm diameter; without mucro at the base of the arms; inhabits pine-oak forests; plants of Durango; elevations of 2,100-2,600 m
...……...……..……...……..... *Tigridia estelae* (Figure 4S)
47. Flowers 4.0-5.0 cm in diameter; with mucro at the base of the arms; inhabits forests of *Abies* and pine; plants of Estado de México and Morelos; elevations of 2,700-3,000 m..... *Tigridia matudae* (Figures 5K-L)
45. Tepals purple or pink
48. Interior tepals notched with a claw 5-6 mm long; of wide distribution in Mexico and Venezuela; elevations of 1,600-3,600 m…….....
…….....….... *Tigridia multiflora* (Figure 5T)
48. Interior tepals apiculate with a claw 1 mm long

49. Flowers 0.8 to 1.5 cm in diameter; plants of Oaxaca and Guatemala; elevations of 1,900-2,300 m.....…..…*Tigridia molseediana* (Figure 5R)
49. Flowers 1.6 to 2.5 cm in diameter
50. Anthers oblong with a sterile apiculus 3 mm long; plants of Estado de México and Hidalgo; elevations of 2,450-3,450 m……..... ……..…..…..*Tigridia alpestris* ssp. *alpestris* (Figure 4D)
50. Anthers oblong obtuse, without sterile apiculus; plants of Estado de México and Michoacán; elevations of 2,500-3,500 m..…….....…… ...……..……..……*Tigridia alpestris* ssp. *obtusa* (Figure 4E)

31. Flowers nutant
51. Apex of the tepals cirrhous
52. Plants of 95-180 cm; tepals yellow; exterior tepals 6-7 cm long; interior tepals 2.5-3.0 cm long; plants of Oaxaca and Puebla; elevations of 1,400-2,400 m….....…*Tigridia illecebrosa* (Figure 5E)
52. Plants of 25-80 cm; tepals pink; exterior tepals 1.5-2.6 cm long; interior tepals 0.6-2.6 cm long
53. Apex of the interior tepal developed, conspicuous and retrorse; nectaries in the form of a V; plants of wide distribution in Mexico and Guatemala; elevations of 300-3,000 m……... … ……..…...……...*Tigridia meleagris* (Figures 5M-N)
53. Apex of the interior tepal reduced; nectaries in the form of a U; plants of Oaxaca; elevations of 2,300-2,500 m……..... .....…….....*Tigridia amatlanensis* (Figure 4F)
51. Apex of the tepals not cirrhous
54. Apex of the interior tepal inflexed
55. Tepals color pink; apex of the interior tepal touching the staminal column; plants of Guerrero, Oaxaca and Veracruz; elevations of 1,600-2,400 m……..…… *Tigridia galanthoides* (Figures 4U-V)
55. Tepals yellowish green; apex of the interior tepal not touching the staminal column; plants of Hidalgo, Puebla and Tlaxcala; elevations of 2,100-2,700 m... *Tigridia vanhouttei* ssp. *roldanii* (Figures 6K-L)
54. Apex of the interior tepal reflexed
56. Plants of 30-60 cm; tepals color brown or purple; exterior tepals apiculate
57. Tepals brown; nectary triangular; plants of Estado de México; elevations of 1,900-2,200 m..*Tigridia hallbergii* ssp. *lloydii* (Figure 5A)
57 Tepals purple; nectary orbicular; plants of Chiapas, Guerrero, Oaxaca, Puebla and Guatemala; elevations of 1,000-3,000 m…..... ....……..…… *Tigridia hallbergii* ssp. *hallbergii* (Figure 4Y)
56. Plants of 70-80 cm; tepals color yellowish-white or pale yellow; exterior tepals notched
58. Tepals yellowish-white; exterior tepals rhomboid; flowers in July-August; inhabits tropical deciduous forests; plants of wide distribution in Mexico; elevations of 700-2,900 m……...…… ....….....… *Tigridia eherenbergii* ssp. *eherenbergii* (Figure 4Q)
58. Tepals pale yellow; exterior tepals orbicular; flowers in September; inhabits forests of *Juniperus*; plants of Hidalgo, Querétaro and San Luis Potosí; elevations of 650-2,300 m……. ….....… .....… *Tigridia eherenbergii* ssp. *flaviglandifera* (Figure 4R)

26. Interior tepals with nectaries protected by a fold
59. Flowers 10-15 cm in diameter; staminal column 6 cm long; anthers ascendant, incurved; plants of wide distribution in Mexico, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala and Honduras; elevations of 500-2,800 m…..... …….....*Tigridia pavonia* (Figures 5V-Y)

59. Flowers less than 10 cm in diameter; staminal column 0.5-1.5 cm long; anthers divaricate, reclinate, recurved
60. Tepals discolorous
61. Basal part of the tepals white
62. Basal leaves developed after flowering
63. Apex of the tepal exterior emarginate; interior tepals rhomboid; inhabits in partially flooded plains; plants of Chiapas; elevations of 2,200-2,400 m *Tigridia chiapensis* (Figures 4K-L)
63. Apex of the tepal exterior apiculate; interior tepals lanceolate; inhabits in tropical deciduous forest and its transition with oak forest; plants of Jalisco and Nayarit; elevations of 300-2,100 m…….....*Tigridia mexicana* ssp. *passiflora* (Figure 5Q)
62. Basal leaves developed before flowering
64. Tepals forming a closed deep cup; style arm branches white; mucro 1.1-2 mm long; plants of Guerrero; elevations of 2,100-2,900 m……....…….… *Tigridia hintonii* (Figure 5B)
64. Tepals forming an open shallow cup; style arm branches yellow; mucro 0.9-1 mm long; plants of Morelos; elevations of 2,200-2,500 m.…….....…...… *Tigridia tepoxtlana* (Figure 6J)
61. Basal part of tepals blue or blueish-purple
65. Tepals forming a closed deep cup
66. Interior tepals with a claw 4 mm long; anthers touching the limb of the of the exterior tepals; staminal column 3-4 mm long; style arms 4 mm long; plants of Jalisco; elevations of 1,200-2,300 m..... *Tigridia mexicana* ssp. *lilacina* (Figure 5O)
66. Interior tepals without claw; anthers not touching the limb of the exterior tepals; staminal column 5-6 mm long; style arms 6 mm long; plants of Jalisco, Estado de México, Michoacán, Puebla and Zacatecas; elevations of 900-2,900 m …….. *Tigridia augusta* (Figures 4G-H)
65. Tepals forming an open shallow cup
67. Exterior tepals 3.0-3.5 cm long; apex of the tepal interior developed, constricted at its base; plants of Durango and Michoacán; elevations of 2,100-3,000 m…….. ...……...…. *Tigridia durangense* (Figures 4O-P)
67. Exterior tepals 2.0-2.5 cm long; apex of the tepal interior reduced, not constricted at its base; plants of Oaxaca and Guatemala; elevations of 1,700-3,100 m…….. ……..…….. *Tigridia seleriana* (Figures 6G-H)
60. Tepals concolorous
68. Tepals red; plants of Estado de México; elevations of 1,500-1,700 m…..…..... *Tigridia mortonii* (Figures 5S)
68. Tepals yellow
69. Plants blooming in the afternoon; plants of Durango, Guanajuato, Jalisco, Nayarit and Zacatecas; elevations of 1,400-2,600 m…...…..…… *Tigridia dugesii* (Figure 4N)
69. Plants blooming in the morning
70. Basal leaves developed after flowering; flowers 3 cm in diameter; staminal column of 5-6 mm; inhabits on plains; plants of Estado de México; elevations of 1,500-2,200 m.....*Tigridia mexicana* ssp. *mexicana* (Figure 5P)
70. Basal leaves developed before or during flowering; flowers 4-6 cm in diameter; staminal column of 1-1.2 cm; inhabits in pine-oak forests; plants of Jalisco; elevations of 700-2,300 m…..... *Tigridia chrysantha* (Figure 4M)

Clave para la identificación de las especies de Tigridieae en Norte América

1. Ripidios fasciculados, 1-6, sésiles, 1 flor por ripidio; flores sésiles; tépalos blancos; filamentos libres; ramas del estilo muy reducidas, difícilmente distinguibles del estilo, a veces representadas por pequeños lóbulos; dehiscencia de las cápsulas por tres suturas; plantas de amplia distribución en México y América del Sur; elevaciones de 0-2,400 m.. *Cipura campanulata* (Figuras 2U-V)
1. Ripidios solitarios, sésiles o pedunculados, con 2 a varias flores; flores pedunculadas; tépalos de varios colores; filamentos libres o connados; ramas del estilo conspicuas, enteras, bifurcadas, bífidas, filiformes o variadamente elaboradas; dehiscencia de las cápsulas por tres suturas apicales
2. Filamentos libres
3. Ramas del estilo bifurcadas, amarillas
4. Tépalos interiores y exteriores subiguales en tamaño, azules; brazos filiformes, retusos; plantas de Jalisco y Michoacán; elevaciones de 1,300-2,000 m.... *Cardiostigma hintonii* (Figuras 2N-O)
4. Tépalos interiores muy reducidos en tamaño, blancos; los interiores con dos máculas amarillas; plantas de Oaxaca; elevaciones de 1,800-2,900 m…..... *Ainea conzattii* (Figuras 2A-B)
3. Ramas del estilo enteras, blancas o azules
5. Ramas del estilo conspicuas
6. Ramas del estilo flabeliformes: ápice de cada antera adpreso a la rama del estilo por debajo del estigma; estigma petaloide o crestado; bulbos con túnicas pardas
7. Ramas del estilo de 11-12 mm de long. incluyendo las crestas estigmáticas; columna debajo de las ramas de 6-7 mm de long.; anteras de 3.5-4 mm de long.; filamentos de 4.5-5 mm de long.; tépalos con una uña estrecha de 1 cm de long., bien definida; tépalos interiores puberulentos en la base del limbo, con pelos glandulares, de 0.1 a 0.3 mm de long.; plantas de Guerrero, Jalisco y Michoacán; elevaciones de 0-1,200 m…. *Larentia mexicana* (Figuras 3J-K)
7. Ramas del estilo de 15 a 19 mm de long., incluyendo las crestas estigmáticas; columna debajo de las ramas de 10 a 12 mm de long.; anteras de 5.5-6(-7) mm de long.; filamentos 6-7 mm de long., segmentos del perianto clavados, obovado-cuneados; base del limbo sin pelos glandulares; plantas de Nayarit y Sinaloa; en elevaciones de 0-500 m..…….. *Larentia rosei* (Figuras 3L-M)
6. Ramas del estilo filiformes; ápice de cada antera no adpreso a la rama del estilo por debajo del estigma; estigma subulado; bulbos con túnicas rojizas; plantas de amplia distribución en México, Guatemala y Honduras; en elevaciones de 0-2,400 m….. *Eleutherine latifolia* (Figuras 3D-E)
5. Ramas del estilo inconspicuas, lobadas o reducidas a una superficie estigmática
8. Ramas del estilo blancas; plantas de México
9. Hoja caulinar envolviendo y sobrepasando el ripidio; inflorescencia sésil; ramas del estilo lobadas; estigma cuneados, ciliados y puberulentos; plantas de Durango, Guerrero, Jalisco, Estado de México, Michoacán y Nayarit; elevaciones de 1,000-3,200 m……..……..... ……...……..…. *Cardiostigma longispatha* (Figuras 2P-R)
9. Hoja caulinar insertada de 2-7 cm debajo del ripidio y sobrepasándolo; inflorescencia pedunculada; ramas del estilo reducidas a la superficie estigmática; estigmas cuneado-reniformes, puberulentos; plantas del Estado de México y Michoacán; elevaciones de 700-2,500 m....…….*Cardiostigma mexicana* (Figuras 2S-T)
8. Ramas del estilo azules; plantas de Florida; elevaciones de 0-100 m……..... ……..……..……...…….. *Salpingostylis coelestina* (Figuras 3U-V)
2. Filamentos connados
10. Ramas del estilo enteras; anteras con dehiscencia poricida; tépalos blancos, concoloros; de plantas de Chiapas, Guatemala y Honduras; elevaciones de 1,000-2,000 m……..... ……..……..……..... *Cobana guatemalensis* (Figuras 2W-X)
10. Ramas del estilo bifurcadas; anteras con dehiscencia poricida o longitudinal; tépalos de diferentes colores
11. Filamentos de menos de 3 mm de long.; anteras con dehiscencia poricida.
12. Tépalos blancos, con 2 máculas amarillas en la base de tépalo interior; plantas de Guerrero, Estado de México, Morelos y Puebla; elevaciones de 800-2,200 m…..... ……...…..……...……..... *Sessilanthera latifolia* (Figuras 4A-C)

12. Tépalos amarillos, con máculas de color púrpura en su base
13. Tépalos amarillo-limón; máculas púrpura dentro de una mancha amarilla en la base de los tépalos interiores; habitan en bosque de pino-encino; plantas de Guerrero; elevaciones de 900-2,200 m..... *Sessilanthera citrina* (Figura 3W)
13. Tépalos amarillo-brilloso, con máculas púrpura en la base de los tépalos interiores y exteriores; habitan en bosque tropical caducifolio y bosque de encino; plantas de Guerrero; elevaciones de 850-2,200 m..... *Sessilanthera heliantha* (Figuras 3X-Y)

11. Filamentos de más de 3 mm de long.; anteras con dehiscencia longitudinal
14. Nectarios ausentes en la superficie adaxial de los tépalos
15. Tépalos azules o blancos
16. Hojas caulinares bien desarrolladas, de 5-11 mm de ancho; plantas de Alabama, Arkansas, Kansas, Lousiana, Mississippi, Missouri, Oklahoma y Texas; elevaciones de 0-2,400 m..... *Nemastylis geminiflora* (Figuras 3P-Q)
16. Hojas caulinares reducidas, si desarrolladas de 1-4 mm de ancho
17. Tallo floral ramificado; plantas con floración en otoño; plantas de Florida; altitudes de 0-50 m..... *Nemastylis floridana* (Figuras 3N-O)
17. Tallo floral no ramificado; plantas con floración en primavera y verano
18. Brazos del estilo de 2 mm de long., más cortos que las anteras; plantas con floración en primavera; plantas de Missouri; elevaciones de 200-500 m..... *Nemastylis nutallii* (Figura 3R)
18. Brazos del estilo de 4 mm de long., más largos que las anteras; plantas con floración en verano; plantas de amplia distribución en México, Texas, Arizona, Guatemala y Honduras; elevaciones de 50-3,000 m..... *Nemastylis tenuis* (Figuras 3S-T)
15. Tépalos amarillos
19. Tallo floral, pedúnculo, pedicelos y frutos alados; tépalos amarillo-tenue; plantas de Jalisco; elevaciones de 400-500 m..... *Colima tuitensis* (Figuras 3A-C)
19. Tallo floral, pedúnculo, pedicelos y frutos no alados; tépalos amarillo-brillante; plantas de Colima; elevaciones de 400-800 m..... *Colima convoluta* (Figuras 2Y-Z)

14. Nectarios presentes en la superficie adaxial de los tépalos interiores, exteriores o ambos
20. Tépalos interiores y exteriores con nectarios formados de tricomas secretores de aceite (elaioforos)
21. Tépalos exteriores e interiores iguales o subiguales en tamaño; anteras con un amplio conectivo, panduradas, erectas
22. Anteras amarillas; plantas de Sinaloa y Nayarit; elevaciones de 0-500 m..... *Alophia intermedia* (Figuras 2F-G)
22. Anteras de color púrpura; plantas de la vertiente del Golfo de México
23. Tépalos interiores extendidos; plantas de Campeche, Chiapas, Tabasco, Veracruz, Yucatán, Belice, Costa Rica, Guatemala, Honduras y Nicaragua; elevaciones de 0-500 m..... *Alophia silvestris* (Figuras 2H-J)
23. Tépalos interiores geniculados
24. Hojas basales 1-2; tépalos interiores con una uña bien definida; plantas de Chiapas, Oaxaca, Querétaro, San Luis Potosí, Tabasco, Tamaulipas, Veracruz y de amplia distribución en Estados Unidos; elevaciones de 0-900 m..... *Alophia drummondii* (Figuras 2C-E)
24. Hojas basales 2-3; tépalos interiores sin una uña bien definida; plantas de Veracruz; elevaciones de 0-200 m..... *Alophia veracruzana* (Figuras 2K-M)
21. Tépalos exteriores más grandes que los interiores; anteras no panduradas, ascendentes; plantas de Florida y Texas; elevaciones de 0-200 m..... *Herbertia lahue* ssp. *caerulea* (Figuras 3H-I)
20. Tépalos exterioriores sin nectarios; tépalos interiores con nectarios formados de tricomas secretores de néctar
25. Ramas del estilo erectas, papilosas y estigmáticas; plantas de Oaxaca; elevaciones de 1,400-2,600 m..... *Fosteria oaxacana* (Figuras 3F-G)
25. Ramas del estilo ascendentes, divaricadas o reclinadas, glabras; estigma apical y subulado

26. Tépalos interiores con nectarios expuestos
27. Tépalos rojos, flores polinizadas por colibríes
28. Flores erectas o ascendentes
29. Flores erectas; tépalos interiores exertos, de la misma longitud que la columna estaminal; brazos del estilo sin mucrón; plantas de Chiapas, Oaxaca, Veracruz y Guatemala; elevaciones de 1,000-3,200 m..... *Tigridia orthantha* (Figura 5U)
29. Flores ascendentes; tépalos interiores inclusos, de menor tamaño que la columna estaminal; brazos del estilo con un pequeño mucrón; plantas de Guerrero; elevaciones de 1,800-3,200 m……..... *Tigridia inusitata* (Figura 5G)
28. Flores nutantes
30. Tépalos exteriores con máculas púrpura; brazos del estilo con un mucrón; plantas de Michoacán; elevaciones de 1,900-2,400 m.... *Tigridia flammea* (Figura 4T)
30. Tépalos exteriores inmaculados; ramas de los brazos del estilo sin mucrón; plantas de Chiapas, Oaxaca y Guatemala; elevaciones de 1,800-3,000 m.…..... ……..... *Tigridia immaculata* (Figura 5F)
27. Tépalos blancos, amarillos, azules, púrpura, rosados y blanco-amarillentos; flores polinizadas por moscas, abejas y abejorros
31. Flores erectas
32. Ápice de los tépalos cirroso; flores abriendo por la tarde; plantas de San Luis Potosí; elevaciones de 1,600-1,800 m……..... *Tigridia catarinensis* (Figura 4J)
32. Ápice de los tépalos no cirrosos; flores abriendo por la mañana
33. Flores de 8 cm de diámetro; ápice de los tépalos interiores atenuado; capsulas globosas; plantas de Puebla; elevación de 1,700 m.…..... *Tigridia purpusii*
33. Flores de 0.8-5 cm de diámetro; ápice de los tépalos interiores acuminado, agudo, obtuso o retuso; cápsulas clavadas a clavado-oblongas
34. Tépalos discoloros
35. Ápice del tépalo interior muy reducido
36. Tépalos formando un taza amarilla, su parte distal blanca; crece en terrenos de cultivo; plantas de Oaxaca; elevaciones de 2,380-2,445 m……..... ……. *Tigridia mariaetrinitatis* (Figura 5H)
36. Tépalos formando un taza blanca o purpura
37. Tépalos formando una taza blanca, maculada y urceolada; plantas de Jalisco y Michoacán; elevaciones de 1,700-2,800 m.... *Tigridia pulchella* (Figuras 6D-E)
37. Tépalos formando una taza púrpura, maculada o estriada, no urceolada
38. Tépalos exteriores apiculados; tépalos interiores sagitados; axila de las hojas caulinares con bulbillos; plantas de Jalisco; elevaciones de 1,900-2,100 m ……..... *Tigridia pugana* (Figuras 6B-C)
38. Tépalos exteriores emarginados; tépalos interiores circulares; axila de las hojas caulinares sin bulbillos; plantas de Oaxaca; elevaciones de 1,800-2,600 m ……..... *Tigridia bicolor* (Figura 4I)
35. Ápice del tépalo interior desarrollado, conspicuo y retrorso
39. Diámetro de la flor de 5 cm; taza amarillenta y maculada; plantas de Querétaro y Veracruz; elevaciones de 1,000-2,600 m.…..... ……. *Tigridia rzedowskiana* (Figura 6F)
39. Diámetro de la flor menor de 5 cm; taza blanca, maculada o estriada
40. Taza estriada
41. Tépalo interior con una uña de 5-6 mm de long.; plantas de San Luis Potosí; elevaciones de 1,996-2,352 m.…..… *Tigridia potosina* (Figura 6A)
41. Tépalo interior con una uña de 2 mm de long.; plantas de Jalisco; elevaciones de 2,100-2,800 m ..... *Tigridia suarezii* (Figura 6I)
40. Taza maculada
42. Plantas de 30-60 cm; anteras estériles en la mitad distal, 12-13 mm de long.; columna estaminal de 4-5 mm de long.; plantas de Michoacán; elevaciones de 2,500-2,900 m.... ……..…..…… *Tigridia venusta* (Figuras 6O-P)
42. Plantas de 40-45 cm de alto; anteras fértiles en toda su longitud, de 6.5 mm

de long.; columna estaminal de 10 mm de long.; plantas del Estado de México y Michoacán; elevaciones de 2,900-3,000 m..... *Tigridia gracielae* (Figuras 4W-X)

34. Tépalos concoloros o uniformemente maculados, variegados o estriados
43. Ápice del tépalo interior muy reducido
44. Tépalos formando una taza abierta; tépalos interiores reniformes; columna estaminal exserta; plantas de Oaxaca y Puebla; elevaciones de 1,500-2,100 m..... *Tigridia huajuapanensis* (Figuras 5C-D)
44. Tépalos formando una taza profunda; tépalos interiores circulares; columna estaminal inclusa; plantas de la Ciudad de México, Estado de México, Hidalgo, Morelos, Querétaro, San Luis Potosí, Tlaxcala y Veracruz; elevaciones de 2,200-2,900 m..... *Tigridia vanhouttei* ssp. *vanhouttei* (Figuras 6M-N)
43. Ápice del tépalo interior desarrollado, conspicuo y retrorso
45. Tépalos de color blanco-amarillento, púrpura azulado
46. Taza maculada; brazos del estilo de color blanco; plantas de Hidalgo; elevaciones de 2,900-3,000 m..... *Tigridia martinezii* (Figuras 5I-J)
46. Taza estriada; brazos del estilo de color rosado
47. Flores de 5.5-6.5 cm de diámetro; sin mucrón en la base de los brazos; habita en bosques de pino-encino; plantas de Durango; elevaciones de 2,100-2,600 m..... *Tigridia estelae* (Figura 4S)
47. Flores de 4.0-5.0 cm de diámetro; con mucrón en la base de los brazos; habita en bosques de *Abies* y pino; plantas del Estado de México y Morelos; elevaciones de 2,700-3,000 m..... *Tigridia matudae* (Figuras 5K-L)
45. Tépalos de color púrpura o rosado
48. Tépalos interiores emarginados con una uña de 5-6 mm de long.; de amplia distribución en México y Venezuela; elevaciones de 1,600-3,600 m..... *Tigridia multiflora* (Figura 5T)
48. Tépalos interiores apiculados con una uña de 1 mm de long
49. Flores de 0.8 a 1.5 cm de diámetro; plantas de Oaxaca y Guatemala; elevaciones de 1,900-2,300 m..... *Tigridia molseediana* (Figura 5R)
49. Flores de 1.6 a 2.5 cm de diámetro
50. Anteras oblongas con un apículo estéril de 3mm de long.; plantas del Estado de México e Hidalgo; elevaciones de 2,450-3,450 m..... *Tigridia alpestris* ssp. *alpestris* (Figura 4D)
50. Anteras oblongas obtusas, sin apículo estéril; plantas del Estado de México y Michoacán; elevaciones de 2,500-3,500 m..... *Tigridia alpestris* ssp. *obtusa* (Figura 4E)

31. Flores nutantes
51. Ápice de los tépalos cirroso
52. Plantas de 95-180 cm de alto; tépalos amarillos; tépalos exteriores de 6-7 cm de long.; tépalos interiores de 2.5-3.0 cm de long.; plantas de Oaxaca y Puebla; elevaciones de 1,400-2,400 m..... *Tigridia illecebrosa* (Figura 5E)
52. Plantas de 25-80 cm de alto; tépalos rosados; tépalos exteriores de 1.5-2.6 cm de long; tépalos interiores de 0.6-2.6 cm de long
53. Ápice del tépalo interior desarrollado, conspicuo y retrorso; nectarios en forma de V; plantas de amplia distribución en México y Guatemala; elevaciones de 300-3,000 m..... *Tigridia meleagris* (Figuras 5M-N)
53. Ápice del tépalo interior reducido; nectarios en forma de U; plantas de Oaxaca; elevaciones de 2,300-2,500 m..... *Tigridia amatlanensis* (Figura 4F)
51. Ápice de los tépalos no cirroso
54. Ápice del tépalo interior inflexo

55. Tépalos de color rosado; ápice del tépalo interno tocando la columna estaminal; plantas de Guerrero, Oaxaca y Veracruz; altitudes de 1600-2400 m…..… *Tigridia galanthoides* (Figuras 4U-V)
55. Tépalos de color verde-amarillento; ápice del tépalo interior no tocando la columna estaminal; plantas de Hidalgo, Puebla y Tlaxcala; elevaciones de 2,100-2,700 m…….....…….....……..... *Tigridia vanhouttei* ssp. *roldanii* (Figuras 6K-L)

54. Ápice del tépalo interior reflexo
56. Plantas de 30-60 cm de long.; tépalos de color marrón o púrpura; tépalos exteriores apiculados
57. Tépalos marrón; nectario triangular; plantas del Estado de México; elevaciones de 1,900-2,200 m.....…....…….....….. *Tigridia hallbergii* ssp. *lloydii* (Figura 5A)
57 Tépalos púrpura; nectario orbicular; plantas de Chiapas, Guerrero, Oaxaca, Puebla y Guatemala; elevaciones de 1,000-3,000 m .....……..... *Tigridia hallbergii* ssp. *hallbergii* (Figura 4Y)
56. Plantas de 70-80 cm de long.; tépalos de color blanco amarillento o amarillo pálido; tépalos exteriores emarginados
58. Tépalos blanco-amarillentos; tépalos exteriores romboides; florece en julio-agosto; habita en bosques tropical caducifolio; plantas de amplia distribución en México; elevaciones de 700-2,900 m…… *Tigridia eherenbergii* ssp. *eherenbergii* (Figura 4Q)
58. Tépalos amarillo-pálido; tépalos exteriores orbiculares; florece en septiembre; crece en bosque de *Juniperus*; plantas de Hidalgo, Querétaro y San Luis Potosí; elevaciones de 650-2,300 m…....….....…..… *Tigridia eherenbergii* ssp. *flaviglandifera* (Figura 4R)

26. Tépalos interiores con nectarios protegidos por un doblez
59. Flores de 10-15 cm de diámetro; columna estaminal de 6 cm de long. anteras ascendentes, incurvadas; plantas de amplia distribución en México, Bolivia, Brasil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala y Honduras; elevaciones de 500-2,800 m……...……....… *Tigridia pavonia* (Figuras 5V-Y)
59. Flores de menos de 6 cm de diámetro; columna estaminal de 0.5-1.5 cm de long.; anteras divaricadas, reclinadas, recurvadas
60. Tépalos discoloros
61. Parte basal de los tépalos blanca
62. Hojas basales desarrolladas después de la floración
63. Ápice del tépalo exterior emarginado; tépalos interiores romboides; habita en llanos parcialmente inundados; plantas de Chiapas; elevaciones de 2,200-2,400 m…….…... ……. *Tigridia chiapensis* (Figuras 4K-L)
63. Ápice del tépalo exterior apiculado; tépalos interiores lanceolados; habita en bosque tropical caducifolio y su transición con el bosque de encino; plantas de Jalisco y Nayarit; elevaciones de 300-2,100 m.....*Tigridia mexicana* ssp. *passiflora* (Figura 5Q)
62. Hojas basales desarrolladas antes de la floración
64. Tépalos formando una taza cerrada y profunda; ramas de los brazos del estilo de color blanco; mucrón de 1.1-2 mm de long.; plantas de Guerrero; elevaciones de 2,100-2,900 m…... .....……..……....…… *Tigridia hintonii* (Figura 5B)
64. Tépalos formando una taza abierta y poco profunda; ramas de los brazos del estilo de color amarillo; mucrón de 0.9-1 mm de long.; plantas de Morelos; elevaciones de 2,200-2,500 m.... ..……..……..…… *Tigridia tepoxtlana* (Figura 6J)
61. Tépalos de color azul o púrpura azulado

65. Tépalos formando una taza cerrada y profunda
66. Tépalos interiores con una uña de 4 mm de long.; anteras tocando el limbo de los tépalos exteriores; columna estaminal de 3-4 mm de long.; brazos del estilo de 4 mm de long.; plantas de Jalisco; elevaciones de 1,200-2,300 m…….…… ……. *Tigridia mexicana* ssp. *lilacina* (Figura 5O)
66. Tépalos interiores sin uña; anteras no tocando el limbo de los tépalos exteriores; columna estaminal de 5-6 mm de longitud; brazos del estilo de 6 mm de long.; plantas de Jalisco, Estado de México, Michoacán, Puebla y Zacatecas; elevaciones de 900-2,900 m..... *Tigridia augusta* (Figuras 4G-H)
65. Tépalos formando una taza abierta y poco profunda
67. Tépalos exteriores de 3.0-3.5 cm de long.; ápice del tépalo interior desarrollado, constricto en su base; plantas de Durango y Michoacán; elevaciones de 2,100-3,000 m…..... ……...… *Tigridia durangense* (Figuras 4O-P)
67. Tépalos exteriores de 2.0-2.5 cm de long.; ápice del tépalo interior reducido, no constricto en su base; plantas de Oaxaca y Guatemala; elevaciones de 1,700-3,100 m……..... .....…….……..……..... *Tigridia seleriana* (Figuras 6G-H)
60. Tépalos concoloros
68. Tépalos rojos; plantas del Estado de México; elevaciones de 1,500-1,700 m.…..... *Tigridia mortonii* (Figuras 5S)
68. Tépalos amarillos
69. Plantas floreciendo en la tarde; plantas de Durango, Guanajuato, Jalisco, Nayarit y Zacatecas; elevaciones de 1,400-2,600 m.....…...… *Tigridia dugesii* (Figura 4N)
69. Plantas floreciendo en la mañana
70. Hojas basales desarrolladas después de la floración; flores de 3 cm de diámetro; columna estaminal de 5-6 mm de long.; habita en llanos; plantas del Estado de México; elevaciones de 1,500-2,200 m..….....…….. ……... *Tigridia mexicana* ssp. *mexicana* (Figura 5P)
70. Hojas basales desarrolladas antes o durante la floración; flores de 4-6 cm de diámetro; columna estaminal de 1-1.2 cm de long.; habita en bosques de pino-encino; plantas de Jalisco; elevaciones de 700-2,300 m.…..... .....….....…….. *Tigridia chrysantha* (Figura 4M)

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