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A New *Gonolobus* Species (Apocynaceae, Asclepiadoideae) from Sinaloa, Mexico †

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Abstract: In this study a new species of *Gonolobus*, *G. villasenorii*, is described. It is endemic to Sinaloa, Mexico, distributed in the Sierra Madre Occidental in pine–oak forest. This species is characterized by the presence of lanceolate sepals, margin of the corolla lobes with a whitish-green callus, without being cristate, and anthers with rectangular dorsal appendages. The new species is compared to *Gonolobus chloranthus* and *Gonolobus erianthus*. *Gonolobus grandiflorus*, *Gonolobus incerianus*, and *Gonolobus lozadae* are species with which it shares reticulate corollas and flowers more than 2 cm in diameter. A detailed description of the new species includes data on its habitat, ecology, phenology, conservation status, a distribution map, and a section where the new species is compared with similar species and how to recognize it.

Keywords: Sierra Madre Occidental; *Gonolobus grandiflorus*; *Gonolobus erianthus*; critically endangered

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1. Introduction

Gonolobus Michx. is one of the most diverse genera of the subtribe Gonolobinae (Apocynaceae, Asclepiadoideae), with just over 130 species. The circumscription of *Gonolobus* was initially proposed by Woodson [1] and subsequently broadened by several other researchers (e.g., [2–5]), and it is currently recognized worldwide to include species with mixed pubescence (long eglandular trichomes and small capitate glandular trichomes), laminar dorsal anther appendages, coroline corolla and, usually, 3–5 winged follicles that are curved at the base. A molecular analysis by Krings et al. [2] suggests that members of *Gonolobus* s.str. share a substitution of thymine for guanine at position 279 of the trnL-F locus (this excludes *G. denticulatus* (Vahl) W.D. Stevens, which was transferred to *Chloropetalum* Morillo [5]. Phylogenies of *Gonolobus* [2,6,7] apparently corroborate the monophyly of the genus; however, given that only 34 species (25%) have been included and that the molecular analyses were performed using different loci and are therefore not necessarily comparable, there continue to be important questions about the clades and relationships within *Gonolobus*.

There are two centers of species diversity for the genus. One stretches from Mexico and northern Mesoamerica to Nicaragua and contains 56–60 species [8,9]. The other extends from southern Mesoamerica to north-northwestern South America [3,5]. There are two species reported in the United States of America; 45 in Mexico; nearly 40 species in Mesoamerica [5,10], several of which are shared with Mexico and South America; 11–12 (endemic) species in the Antilles [2,10]; and approximately 50 in South America [5], resulting in a total of approximately 130 species.

In Mexico, *Gonolobus* is highly diverse and widespread, with presence in all states except Baja California and Coahuila. Among the 45 species recorded in Mexico, more than half (55%) are endemic, and several recent descriptions have expanded our understanding of this diversity [11,12].

While carrying out fieldwork to document the flora of the Sierra Madre Occidental in southeastern Sinaloa, we encountered and studied individuals of a population of *Gonolobus* with a combination of characters that do not correspond with any of the known species in Mexico. Here, we describe these plants and assign them to a new species, comparing them to other species with corolla diameters over 2 cm and conspicuous green reticulates. We include photographic plates and an illustration of the new species, as well as a distribution map.

2. Materials and Methods

Specimen Analysis

During a botanical exploration carried out in the years 2021–2022, in the pine–oak forest on the western slope of the Sierra Madre Occidental, Sinaloa, a flowering and fruiting liana belonging to the Apocynaceae family was located. The plant material was collected, its geographic and ecological data were recorded, and photographs of its structures were taken. The field material was processed following standard procedures [13] and was identified using the generic key elaborated by Alvarado-Cárdenas et al. [9], circumscribing the taxon within the genus *Gonolobus*. The specimens were deposited and analyzed in the CIIDIR and FMCE herbaria. Fresh leaf, flower, and bud material was preserved in 70% ethanol for detailed examination.

Morphological Measurements and Descriptions

All morphological characters useful in the taxonomy of the group, such as habit, plant indumentum, leaf morphology, and flower and gynostegial morphology, were studied and compared following previous studies [12,14,15] and expert knowledge. Measurements of the leaves, inflorescences, flowers and fruits were obtained with the aid of a Mitutoyo digital vernier (CD-6 CSX). Measurements and details of trichomes, as well as floral structures, were obtained under a Nikon stereomicroscope (C-Leds, SMZ445, Tokyo, Japan). The material collected was compared to species of the same genus deposited in the herbaria ENCB, FCME, FEZA, HGOM, HUAP, IBUG, IEB, MEXU, and UAMIZ [16], as well as the descriptions reported in Stevens [10] and Juárez-Jaimes and Lozada-Pérez [17].

Data Processing

Locality information for the compared taxa was gathered from herbarium specimens and the Naturalista digital database [18], and from these a database was generated with more than 300 records for the compared species. Specimens that did not have geographic collection data were georeferenced from the described locality using GEOLocate [19]. The final database was processed using QGIS [20] to obtain the species' distribution maps. The conservation status of the new species was evaluated following the criteria of the IUCN Red List [21] and the informatics tool GeoCAT [22]. We provide additional information on the biology of the species and field observations for the final determination of the risk category according to the IUCN criteria [21].

Species Hypothesis

Systematics, like all sciences, seeks to describe and explain the phenomena around us. Proposed taxa, including species, are at their core an explanatory hypothesis based on abductive reasoning that proposes explanations for the diversity of organisms. These hypotheses require base knowledge and theory that is expected to be observed given the plausible causal condition, as well as the observations that require explanation [23,24]. The main base knowledge for the species hypothesis presented here is the cohesive species concept of Templeton [25], in combination with our observations of morphology and distribution. The cohesive species concept is founded on population genetics but does not disregard other factors of cohesion to explain species recognition. For example, the expression of morphology (restrictions of the phenotypic variability in the individuals)

provides evidence of the tokogenetic relationships among individuals that share similar attributes that are not shared with the individuals associated with other hypotheses (i.e., taxa). These attributes arise among members of an ancestral population through some unspecified evolutionary process (natural selection, genetic drift, self-organization, etc.) and over time are fixed in the members of the current populations. At the same time, the distinctive character of the habitat (geographic distribution, ecological constraints) could play an important role in restricting the distribution of the individuals of the population and keeping them separate from the rest of the individuals of other species. Here, we use these two factors to explain the recognition of the individuals as a species hypothesis. Thus, in the present text, when we refer to taxa or species, we are referring to the individuals associated with the corresponding explanatory hypotheses. Additionally, the proposed name of the new species follows the rules provided in the current International Code of Nomenclature for Algae, Fungi, and Plants [26].

3. Results

Taxonomic Treatment

Gonolobus villasenorii L.O. Alvarado, Pío-León, Morillo et S. Islas sp. nov.

Type—MEXICO: Sinaloa Municipio Concordia, Sierra Agua Zarca or Los Bules, 3.5 km SE of La Petaca, 23°23′43.4″ N, 105°48′42″ W, 1750 m, 21 August 2022, *J. F. Pío-León & M. Pérez 359* (holotype: CIIDIR!; isotypes: FCME! MEXU! USON!).

Diagnosis. Individuals similar to *Gonolobus erianthus* in having flowers of similar size, corolla lobes ovate with flat stylar head with purple margin; the taxon (explanatory hypothesis) proposed here differs by its lanceolate sepals (vs. broadly ovate sepals in *Gonolobus erianthus*), margin of corolla lobes with greenish-white callus, without being cristate (margin with green callus, cristate), and anthers with narrowly rectangular dorsal appendages (vs. quadrangular dorsal appendages).

Perennial vines; latex white; stems with mixed trichomes, glandular trichomes present, ca. 0.5 mm in length, combined with simple adpressed trichomes, from 1 to 1.5 mm long, in two lines along the internodes, denser on the nodes; leaf blades acuminate to mucronate, 4.5–10.6 × 1.7–4.5 cm, base cordate, lobes 3.4–6 × 7–16.0 mm, apex rounded mucronate to acuminate, 6–10 mm long, adaxial surface with adpressed trichomes scattered on the blade, multicellular with septa black, abaxial surface glabrous, with some scattered adpressed trichomes, glandular trichomes scattered along the veins, margins entire, colleters 2–4, 0.25–2.46 mm tall, yellow toward the apex, petioles 3.1–4.6 cm long, indumentum adpressed, trichomes scattered, denser toward the node and at the base of the blade, ca. 0.2 mm, stipule trichomes absent; inflorescence dichasial, axillary; peduncles (4.1–)7.5–19.9 mm long, indumentum adpressed in two lines lengthwise, denser at the insertion of the pedicel; pedicels (1.5–)3.1–28.3 mm long, indumentum adpressed, dense when young, scattered lengthwise when mature; bracts linear-lanceolate, 5.1–9.08 × 0.4–0.6 mm, deciduous, trichomes adpressed scattered, multicellular with septa black, denser on the adaxial face, up to 0.25 mm long; sepals 5, lanceolate, 1.55–2.04 × 0.3–0.45 cm, brown, falcate, apex acute, margin sparsely ciliate, adaxial surface with some scattered adpressed trichomes, 0.27 long, abaxial surface with adpressed trichomes 0.1–0.3 mm long, glandular trichomes fewer up to 0.1 mm largo scattered over the surface; 1 colleter per sinus, ca. 0.3 mm long; corolla 4–5 cm in diameter, green, tube 0.4–0.5 cm tall, limb 1.2 mm wide, adpressed trichomes dense, faucial ring ca. 0.3 mm wide, pentagonal, green, lobes 5, 1.72–2.02 × 0.76–0.97 cm, obliquely ovate-lanceolate, apex acuminate, contorted, adaxial surface with indumentum adpressed, dense at the base, distributed in a triangular shape, right margin with whitish-green callus, with dense adpressed indumentum; gynostegial corona, simple, ciatiform, striate-rugose, margin entire, whitish-green, internally yellow; anthers with dorsal appendages, 0.75–0.80 × 0.82–0.86 mm, narrowly rectangular, reddish-brown, apex slightly bilobulate; stylar head 4.17 mm in diameter, pentagonal, apex flat, yellow with purple margin, stipe ca. 1 mm long; pollinarium with corpuscles 0.1–0.15 mm long, elliptical, translators ca. 0.1 mm long, pollinia borne horizontally, 0.74 × 0.19 mm,

laterally excavated; follicles ovate-fusiform, 9 × 1.3 cm, with 5 small ribs 1–2 mm high. Seeds not observed. Figures 1 and 2.

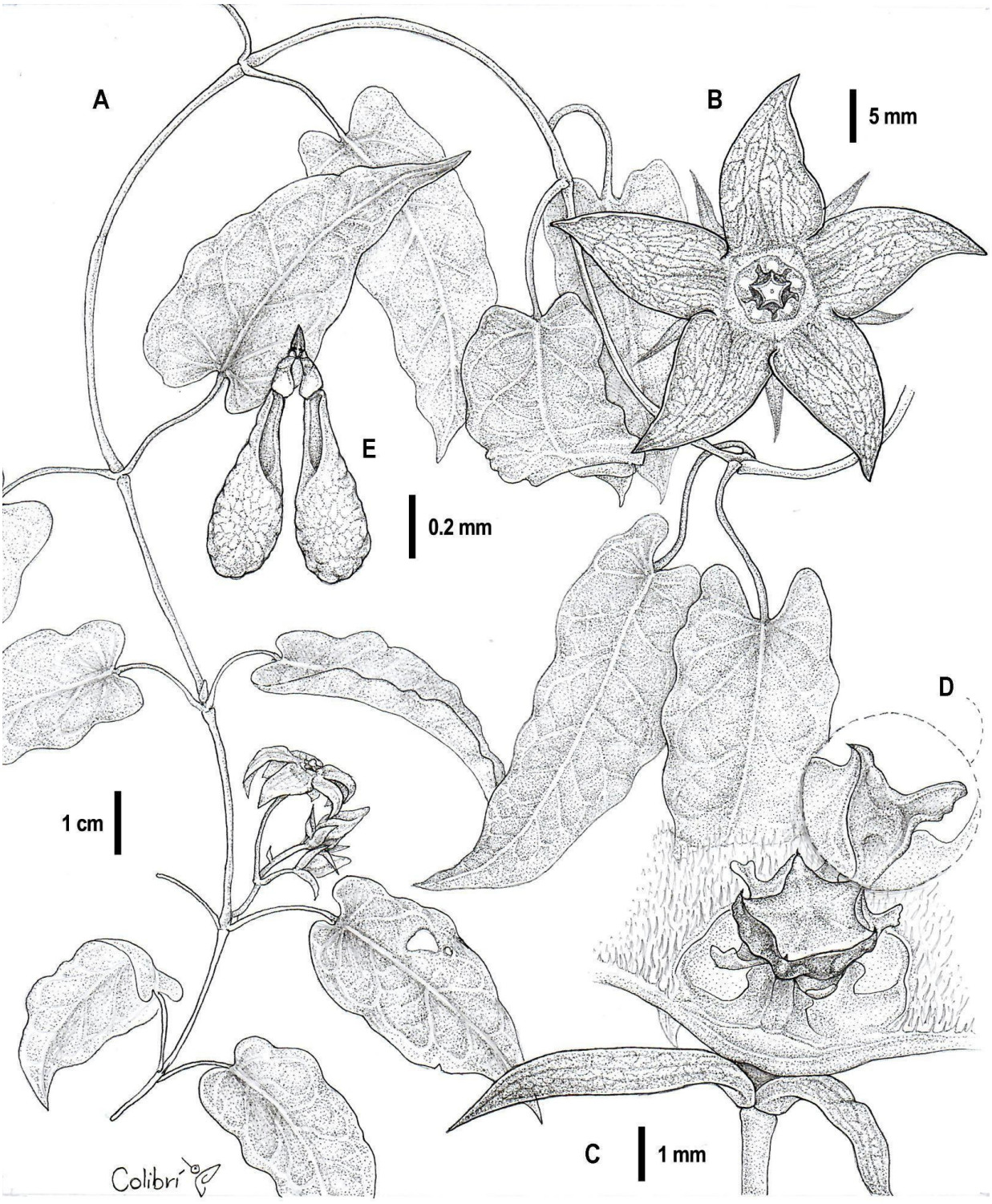

Figure 1. *Gonolobus villasenorii*: (**A**) Branch segment with inflorescence and flower bud. (**B**) Flower. (**C**) Longitudinal section of the flower (**D**) apex of the style head. (**E**) Pollinarium. Illustrations by Quiyahuitl Colibrí Fernández Armendáriz, based on the holotype J. F. Pío-León & M. Pérez 359.

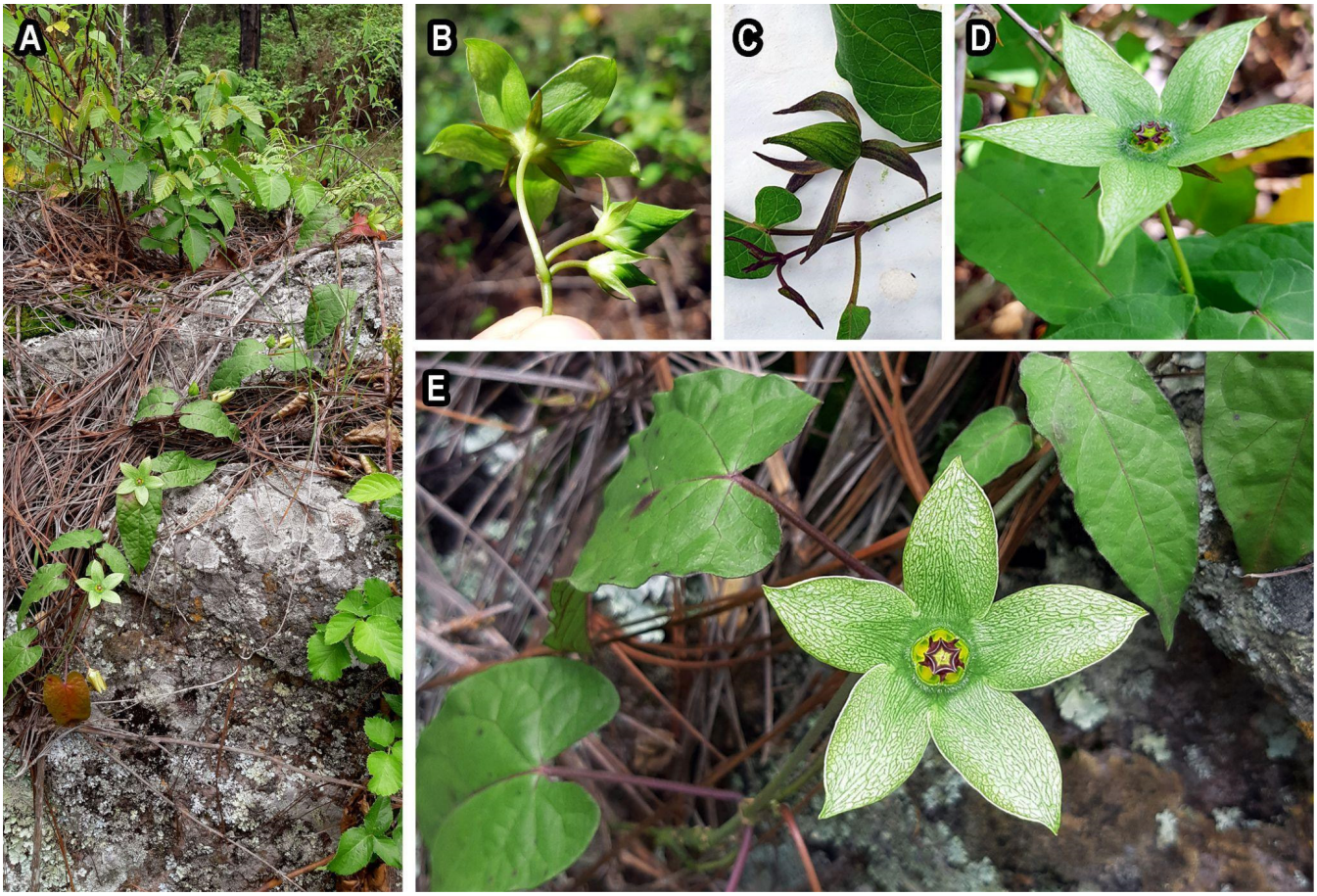

Figure 2. *Gonolobus villasenorii*: (**A**) Branch with leaves. (**B**) Leaves and flower bud. (**C**) Overhead view of the flower. (**D**) Lateral view of the flower. (**E**) Front view of the flower.

Distribution, Habitat, and Ecology

Individuals of this species are known only in Sinaloa (Figure 3) and grow in pine–oak forest dominated by *Pinus oocarpa*, *Arbutus tesellata*, *Quercus subspathulata*, *Quercus viminea*, and *Bejaria mexicana* at elevations around 1700 m. They have been seen in open or impacted valleys dominated by *Rubus palmeri* or in the canopy of shrubs in moist, open canyons with mesophilous elements. The distribution of this species is located in the Tropical Madrean ecoregion on the western slope of the Sierra Madre Occidental [27], which contains some of the warmest *Pinus-Quercus* forest elements of the range.

Phenology

Mature flower buds were observed in July and flowers in August, coinciding with the season of highest precipitation in the region (June through September). Dry fruits from the previous season were observed.

Etymology

The name honors our friend and colleague, Dr. José Luis Villaseñor Ríos, a Mexican botanist who has made important contributions to the knowledge of the systematics and distribution of Asteraceae and the Mexican flora.

Conservation Status

The individuals of this species are restricted to Sinaloa, Mexico, and only two populations close together are known. The population is scarce and distributed in pine–oak forest, it has been observed that in this type of vegetation the extraction of timber resources, as well as livestock farming in the vicinity, can affect the populations. Considering that we only have data from this type of locality, together with the anthropogenic impact, we

suggest the category of Critically Endangered B2ab(ii) according to the red list criteria of the IUCN [22].

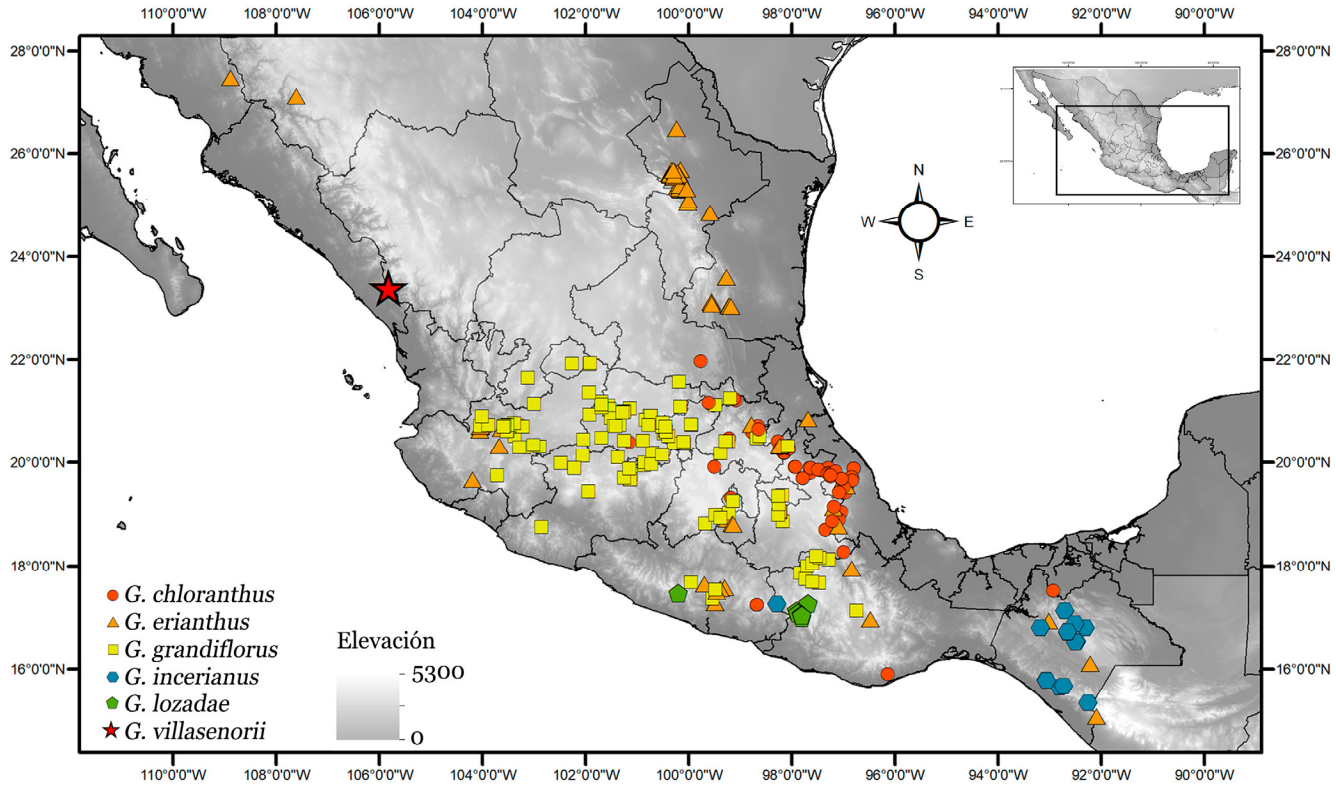

Figure 3. Distribution map for *Gonolobus villasenorii* and morphologically similar species.

Additional specimens analyzed. MEXICO: Sinaloa. Municipio Concordia, Sierra Agua Zarca or Los Bules, 3.5 km SE of La Petaca, 23°23′44″ N, 105°48′42″ W, 1750 m, 24 July 2022, *L. O. Alvarado-Cárdenas, J. F. Pío-León & M. Pérez s.n.* (FCME). Municipio Concordia, road to El Cuatantal, 1.5 km south of La Petaca, 23°24′ 43″ N, 105°48′14″ W, 1670 m, 21 August 2022, *J. F. Pío-León & M. Pérez 361* (CIIDIR, CIAD).

4. Discussion

The addition of this new species of *Gonolobus* brings the total number of species documented in Mexico to 46. This species is the seventh species of *Gonolobus* in Sinaloa and the second endemic species for the state, along with *G. naturalistae*, which is contrasting in morphology and size [9,28]. *Gonolobus villasenorii* increases the endemism for the country to 25 species (54%) and is an interesting addition because it is the eighth species of *Gonolobus* with a very northern distribution in western Mexico. Further analysis of distribution and climatic requirements will be very useful to know the biogeographic patterns of the species of the genus.

In Mexico, there are at least 11 species of *Gonolobus* with reticulate corollas; six of these have flowers more than 2 cm in diameter, comparable to the new taxon: *G. chloranthus*, *G. eriathus*, *G. grandiflorus*, *G. incerianus*, and *G. lozadae* ([10,17]; Figure 4A–F). Of these, *G. eriathus* has the strongest similarity to the new species, since both have corollas with broadly ovate lobes and flat stylar head with purple margin (Figure 4C). The members of *Gonolobus erianthus* are distinguished by their ovate sepals (vs. lanceolate in *G. villasenorii*), the lobes of the corolla with callus margin green and crispate near the apex (vs. margin with whitish-green callus, without being crispate), dorsal anther appendages quadrangular (vs. dorsal anther appendages narrowly rectangular). In the case of the remaining compared species, *G. villasenorii* is distinguished by its ovate corolla lobes (vs. lanceolate in *G. grandiflorus* and oblong in *G. incerianus* and *G. lozadae*; Figure 4D–F), with light green reticulum (vs.

dark green reticulum in *G. incerianus*, Figure 4E) and narrowly rectangular dorsal anther appendages (vs. quadrangular dorsal anther appendages in all other species, Figure 4B–F). In general, the morphological differences among the compared taxa reach the requirements established in the explanatory hypothesis that proposes phenotypic constraints and the similarity of the individuals corresponding to each of the proposed species.

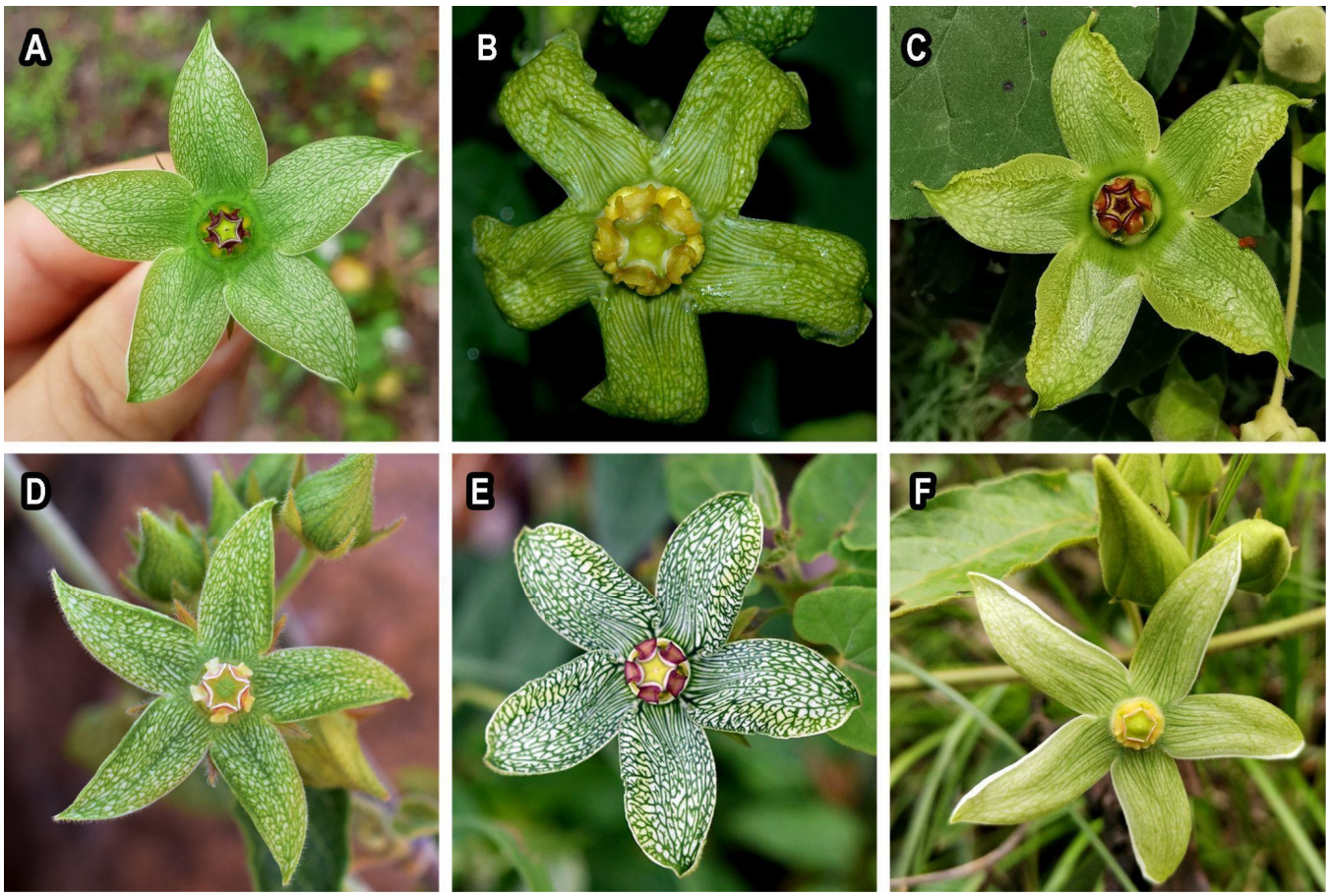

Figure 4. (**A**) *Gonolobus villasenorii* and morphologically similar species. (**B**) *Gonolobus chloranthus* (photo by by Pablo Carrillo Reyes). (**C**) *Gonolobus erianthus* (photo by Pablo Carrillo Reyes). (**D**) *Gonolobus grandiflorus* (photo by María G. Hernández Chávez). (**E**) *Gonolobus incerianus* (photo by Neptalí Ramírez Marcial). (**F**) *Gonolobus lozadae* (photo by Ubaldo Edgar García López).

The distribution of the new species also distinguishes it from previously known comparable species, and the correspondence between morphological differences and the distinction in the habitat provides evidence for the recognition of this species. *Gonolobus villasenorii* is known only in southeastern Sinaloa, in a mountain enclave of the Sierra Madre Occidental. In contrast, *G. grandiflorus* is distributed mainly in the center of the country, and Zacatecas is the northernmost state in which it is recorded; *G. chloranthus* is found in the states of the center and Atlantic slope (Mexico City, Hidalgo, Oaxaca, Puebla, Querétaro, San Luis Potosí, and Veracruz); and *G. incerianus* (Chiapas, Oaxaca and Veracruz) and *G. lozadae* (Guerrero and Oaxaca) are found in the southern part of the country. Of the species compared, the only one previously documented in Sinaloa is the widely distributed *G. erianthus* [22]; they had been collected at different points and elevations of the Sierra Madre Occidental (Figure 3), which may suggest that their environmental requirements are different. However, a larger sampling would yield more information in this regard.

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Data Availability Statement: The database of the specimens used during the analysis and the coordinates used to make the maps are available at the following link: https://docs.google.com/spreadsheets/d/1dPdT8MQXRNrIW7bNi9xgK5eernz_BKGvoKz5oqO7DX0/edit?usp=sharing.

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Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of the data; in the writing of the manuscript; or in the decision to publish the results.

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