

## A new species of *Ceratozamia* (Zamiaceae) from the Sierra Madre of Chiapas, Mexico, with comments on species relationships

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The new species *Ceratozamia vovidesii* from a Pleistocene floristic refuge in southern Mexico is described and illustrated. It shows an affinity with *C. matudae* Lundell and *C. mirandae* Vovides, Pérez-Farrera & Iglesias from Chiapas, but it differs from them in leaf, male and female cones, and trunk morphology. © 2007 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2007, 153, 393–400.

**ADDITIONAL KEYWORDS:** *Ceratozamia* species complex – floristic refuges – Pleistocene – Triunfo Biosphere Reserve.

### INTRODUCTION

The Sierra Madre of Chiapas has been explored and studied by Matuda (1950a,b), Miranda (1957), Breedlove (1981), and Long & Heath (1991). All have recorded this as an area rich in endemisms and Toledo (1982) pointed out the Soconusco area as a Pleistocene floristic refuge. Unfortunately some sites of this geographical region are being clear cut for full sun coffee cultivation and corn plantations, this occurring mainly in the Frailesca and Soconusco regions of central and southern Chiapas respectively. These activities have resulted in the disappearance of forest cover. This has caused local extinction of taxa where some endemic species have been recorded, such as the cycads *Zamia soconuscensis* Schutzman, Vovides & Dehgan and *Ceratozamia matudae* Lundell, as well

as *Anthurium sarukhanianum* Croat; *Eupatorium heathiae* B.L. Turner, *Chamaedorea ibarrae* Hodel & Castillo (Schutzman, Vovides & Dehgan, 1988; Long & Heath, 1991; Croat & Pérez-Farrera, 2000), amongst others.

During a floristic study in the Triunfo Biosphere Reserve, an area located in the middle part of the Sierra Madre of Chiapas, we collected a species of *Ceratozamia* with arched leaves and pendent female cones growing under a *Quercus* and cloud forest canopy on steep slopes.

This species was cultivated along with others, including *C. matudae* (to which we believe it is related) in the greenhouse of the School of Biology of the Universidad de Ciencias y Artes de Chiapas (UNICACH) and Francisco J. Clavijero Botanic Garden in Xalapa, Veracruz, during a period of six years. Observation of stable leaf, leaflet and cone morphology, both in the field and under cultivation has led us to the conclusion that we are dealing with a new species.

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## DESCRIPTION

**CERATOZAMIA VOVIDESII** PÉREZ-FARRERA & IGLESIAS, SP. NOV. (FIGS 1, 2)

*Diagnosis:* Plantae terrestres, humiles 15–85 cm altae caule subglobose vel cylindrico, parvo, semihypogaeo vel aereo; cataphyllis lanatis, triangularibus, foliis pinnatis; petiolo 36–79.5 cm longo; rhachidi 88–126 cm longa; foliis pendentibus et aculeatissimis, foliolis oppositis vel suboppositis, 74–93 jugis, linearibus; strobilis masculinis lineari-cylindricis, 48 cm longis, pedunculo 9 cm longo tomentoso; strobilis fagineis, 33–46 cm decumbentibus longis, pedunculo 9.5–16 cm tomentoso; seminibus 21–22 mm longis.

*Type:* MEXICO, CHIAPAS, Sierra Madre. vii.2001 *M. A. Pérez-Farrera* 2620<sup>a</sup> (Holotype: HEM Isotypes: CHIP, MEXU, XAL, MO).

*Description:* TRUNKS subglobose to cylindrical 15–85 cm long, subterranean to partially aerial, 17.8–32.1 cm diameter, protected by persistent leaf bases, light brown. CATAPHYLLS 55–75 × 27–50 mm, triangular, stipulated, tomentose, light brown. LEAVES 8–16, 124–188 cm, pinnate, erect to arched, inserted spirally on trunk apex forming an open crown, reddish-brown when emerging, dark green when mature. PETIOLES 36–79.5 cm, 8.3–13.4 mm diameter. RACHIS 88–126 cm long, petiole and rachis with short prickles diminishing in number from the petiole towards rachis. LEAFLETS 74–93 pairs, 29–38 × 0.74–1.4 cm, margins entire, inferior tending to be slightly more curved than superior, flat, rarely slightly channelled, slightly linear to falcate, alternate to subalternate in the apical portion of leaf, opposite to subopposite in the middle and basal portions, coriaceous, apex long-acuminate, base attenuate, subrevolute, dark green on the adaxial surface, light green on the abaxial surface, veins 8–13, distance between veins 1–1.5 mm, articulations green. MICROSTROBILUS erect, conical, light green to olive green when emerging, light yellow to creamy yellow when mature, 48 cm, 43 mm diameter in the middle part, peduncle, 9 cm long, 19 mm diameter tomentose, light brown when emerging, dark brown when mature; MICROSPOROPHYLLS numerous, inserted spirally along cone axis forming apparent vertical rows, cuneiform, bicornate at distal end, fertile portion covering 3/4 of the abaxial surface excluding horns; MICROSPORANGIA indefinite in sori of 3–4, longitudinally dehiscent. MEGASTROBILI 33–46 cm, 6.9–9.6 cm diameter in the middle part, cylindrical to barrel shaped, decumbent, olive green at emergence, dark brown at maturity, peduncle 9–16 cm, 13–20 mm diameter, tomentose, brown to reddish; MEGASPOROPHYLLS indefinite, inserted spirally along the cone axis forming apparent vertical rows, peltate, distal face

41–55 × 18.7–27.3 mm, hexagonal, bicornate, with light grey to pink tomentum on lobulate portion near the horns. SEED 23.5–27.4 × 13.4–17.6 mm diameter, ovate, sarcotesta white when immature, creamy-yellow at maturity, sclerotesta smooth, beige to light beige with 9–10 visible lines radiating from micropyle. Chromosome number  $2n = 16$ .

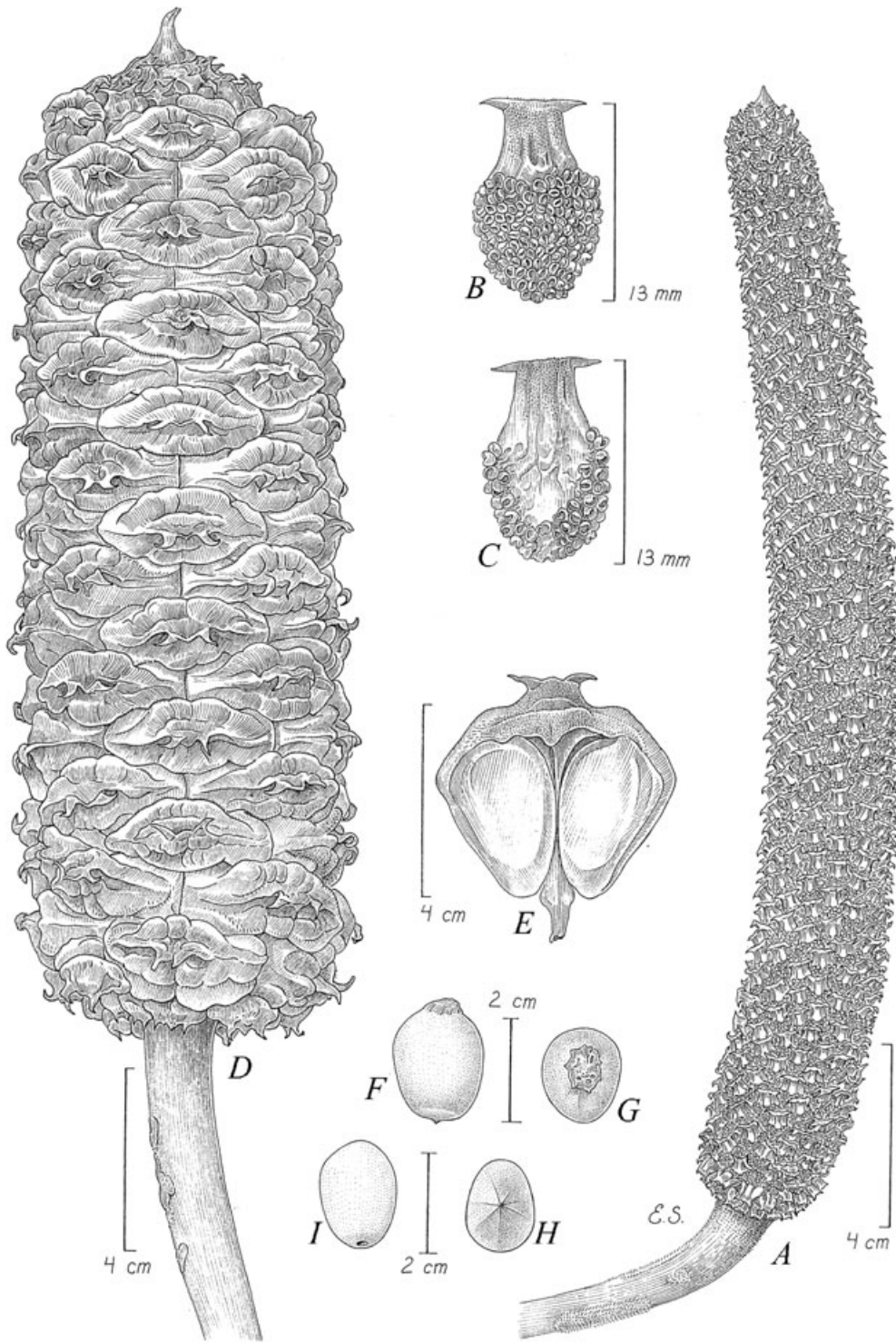
The closest affinity of the new species is with *Ceratozamia matudae*.

*Etymology:* The specific epithet was chosen to honour to Dr Andrew P. Vovides in recognition of his pioneer studies on Mexican cycads which includes systematics and ecology, his tireless efforts to preserve them, as well as the creation of the Mexican National Cycad Collection at the Francisco J. Clavijero Botanic Garden at Xalapa, Veracruz.

*Other vouchers examined:* Chiapas; 1.x.1940, *E. Matuda* 4032 (MEXU); 13.v.1982, *J. I. Calzada, G. Cortez & G. Juarez*, 9134 (XAL); 4.vi.1989 *M. Heath & A. Long* 1287 (CHIP); 5.xi.1988, *Palacios E.* 1050 (CHIP); 11.v.1988, *T. Cabrera Cachón* 0074 (CHIP); 10.v.1988, *G. Rodríguez Guillén* 154 (CHIP); 25.iv.1994, *Farrera-Sarmiento* 474 (CHIP); 11.vii.1995, *M.A. Pérez Farrera* 485 (CHIP); 23.i.1968, *Alush Shilom Ton* 3554 (CAS); 10.v.1988, *Breedlove & Bourell* 67510 (CAS); 11.viii.1981, *Breedlove* 52076; 14.xii.1980, *Breedlove* 48678; 21.x.1980, *Breedlove & Strother* 46728, 46678 (CAS) 5.xi.1988, *Breedlove & Daniel* 71109 (CAS); 8.xi.1945, *Hernández X. & A. Sharp* 402 (MEXU); 25.ii.1951, *Miranda* 7042 (MEXU).

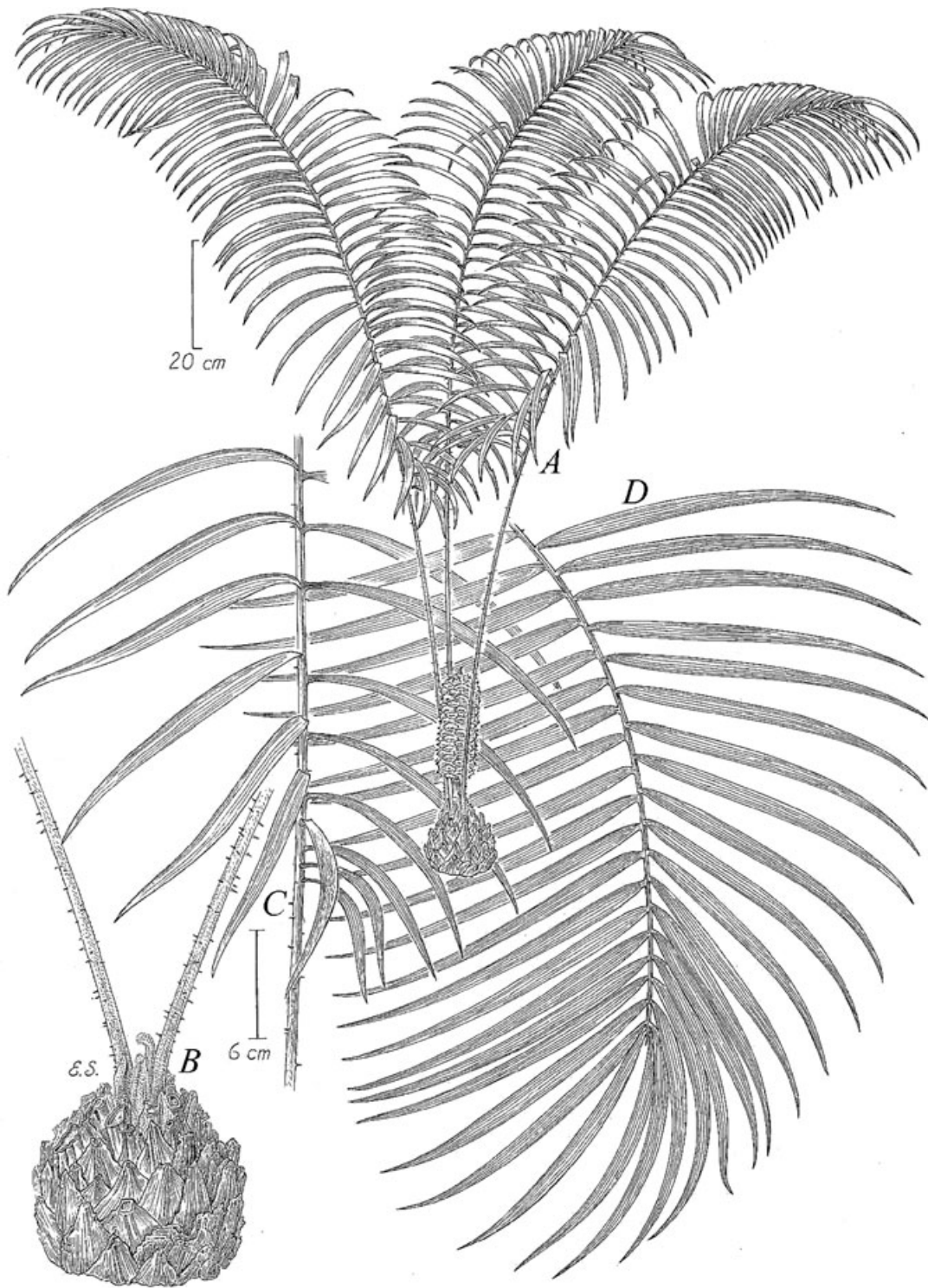
## HABITAT DESCRIPTION

The vegetation type where this species grows is *Quercus* forest (*sensu* Rzedowski, 1978) which is structured into three strata: an upper canopy dominated mainly by *Cornus disciflora* DC., *Quercus magnoliaefolia* Nee, *Quercus salicifolia* Nee, *Ardisia* aff. *escallonioides* A & C., *Pinus oocarpa* Schiede var. *ochoterenai* Martínez; a middle stratum dominated by *Clusia* sp., *Cnidocolus tubulosus* (Muell. Arg.) I.M. Johnston, *Diphysa floribunda* Peyr., *Kohleria deppeana* (Schl. & Cham.) Frisch, *Salvia karwinskii* Beth., *Ocotea acuminatissima* (Lundell) Lorea, *Rapanea myricoides* (Schl.) Lundell, *Ternstroemia tepezapote* S. & C., and finally a lower herbaceous/shrubby layer consisting of *Anthurium lucens* Standl ex Yunker, *Begonia sartorii* Liebm., *Callisia gentlei* Matuda var. *tehuantepecana* (Matuda) D. Hunt, *Euphorbia graminea* Jacq. and *Salvia rubigonosa* Benth. (Bachem & Rojas, 1994). The soil type of this habitat is an acid grey-brown-reddish humic cambisol (Cmu), consisting of a loamy-sandy clay texture with light surface humus. The



*Ceratozamia vovidesii*  
 Col. M. A. Pérez Farrera 2620a  
 Ilus. E. Saavedra

**Figure 1.** *Ceratozamia vovidesii*. A, male strobilus; B, microsporophyll abaxial surfaces; C, microsporophyll adaxial surfaces; D, mature female strobilus; E, megasporophyll and ovules; F, seed, lateral view; G, detail of seed with apical crest; H, I, details of the micropyle.



*Ceratozamia vovidesii*  
Col.  
Ilus. E. Saavedra

**Figure 2.** *Ceratozamia vovidesii*. A, habit of leaves; B, detail of trunk, leaf cataphyll and base of petiole; C, detail base of rhachis and leaflets; D, details of the middle portion of a leaf.

KEY TO SIERRA MADRE *CERATUZAMIA* SPECIES

The following key permits the separation of all *Ceratozamia* species present in the Sierra Madre of Chiapas: *Ceratozamia vovidesii*, *C. matudae*, *C. norstogii*, *C. mirandae* and *C. alvarezii*.

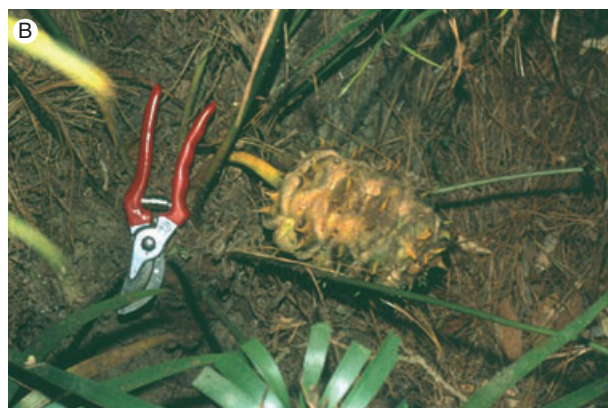
- 1a. Rachis spirally twisted ..... *C. norstogii*
- 1b. Rachis not spirally twisted
  - 2a. Leaflets channelled ..... *C. mirandae*
  - 2b. Leaflets not channelled
    - 3a. Leaflets with yellow articulations ..... *C. matudae*
    - 3b. Leaflets with green articulations
      - 4a. Leaves greater than 124 cm long ..... *C. vovidesii*
      - 4b. Leaves less than 109 cm long ..... *C. alvarezii*

bedrock consists of a complex of Precambrian granites and heavily folded laminated metamorphic rocks. The topography ranges from slight to abrupt with slopes of up to 45° (Bachem & Rojas, 1994). This species can also be found in cloud forest Bosque Mesófilo de Montaña and tropical rain forest Bosque Tropical Perennifolio (*sensu* Rzedowski, 1978). These habitats all lie within an altitudinal range 1000–1700 m a.s.l.

## DISCUSSION

This species was recognized for the first time as a new species during a study of population dynamics of *Ceratozamia matudae*, where geographical distribution patterns were analysed (Pérez-Farrera *et al.*, 2000). This area of southern Mexico is being studied particularly for its floristic hot-spots and Pleistocene refugia. González & Vovides (2002), using molecular data, have pointed out a probable southern Mexican origin for the genus *Ceratozamia* and there appears to be a strong correlation with the presence of cycads in these refugia (Schutzman *et al.*, 1988).

*Ceratozamia vovidesii* is closely related to *C. matudae* in that both species have pendent female cones, but *C. matudae* has a very long, green-yellow, thin and almost glabrous peduncle, whereas that of *C. vovidesii* is short, thick, brown and tomentulose (Fig. 3). Also, *C. vovidesii* differs in trunk morphology, leaf and the colour of the leaflet articulation. In *C. matudae*, the trunks are aerial, un-branched and the leaves erect. In *C. vovidesii*, the trunks are subterranean to aerial and at times branched. In cloud forest and tropical rain forest habitats, the trunks of *C. vovidesii* are often subterranean and the leaves erect. However, in *Quercus* forest the trunks are aerial to subterranean and the leaves arched to erect (Fig. 4). The colour of the leaflet articulation is yellow in *C. matudae* and green in *C. vovidesii* (Fig. 5). Male cones of *C. matudae* are thick, cylindrical and short whereas those of *C. vovidesii* are thin, conical and long (Fig. 6). There are also similarities with *C. mirandae* in respect to colour and leaflet morphology; both have



**Figure 3.** A, habit of mature plant of *C. vovidesii*; note thick tomentulose peduncle of female cone. B, habit of mature *C. matudae*; note longer yellow glabrous peduncle of female cone.

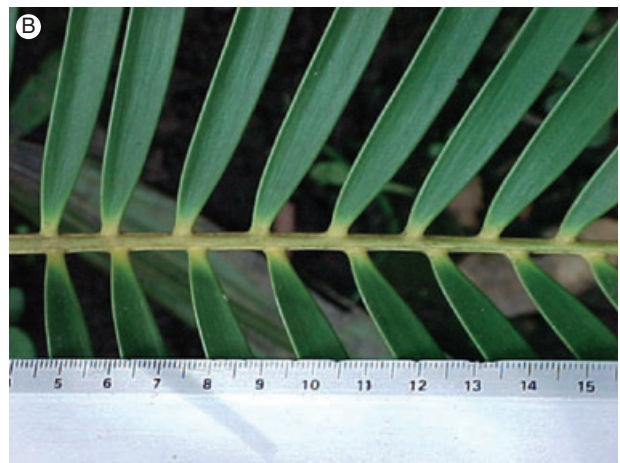
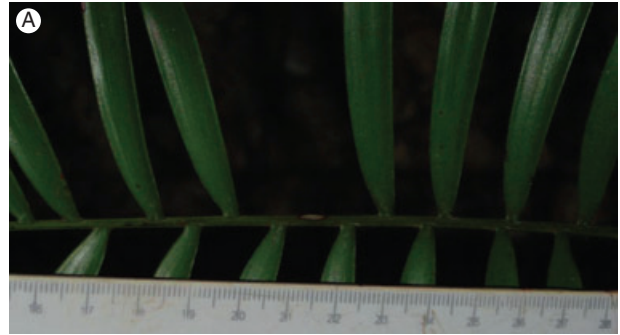
green leaflet articulations and channelled leaflets. In some populations of *C. vovidesii*, the leaflets are slightly channelled but differ in female cone features, habit and trunk morphology. *Ceratozamia mirandae* has erect female cones and unbranched arborescent



**Figure 4.** A, habit of mature leaves of *C. vovidesii*; note arched leaves in *Quercus* forest. B, habit of mature leaves of *C. matudae*; note erect leaves in cloud forest.

trunks. *Ceratozamia vovidesii* has pendent female cones and, at times, branching subterranean trunks.

Due to the leaflet morphology presented by *C. vovidesii*, coriaceous linear-subfalcate leaflets with long-acuminate apices, we include it within the narrow leaflet group of *Ceratozamia* species that includes: *C. mexicana* Brongn., *C. zaragozae* Medellin, *C. matudae* Lundell, *C. kuesteriana* Regel, *C. robusta* Miq., *C. sabatoi* Vovides, Vazq. Torres & Schutzman, *C. alvarezii* Pérez-Farrera, Vovides & Iglesias, *C. norstogii* Stevenson, and *C. mirandae* Vovides, Pérez-Farrera & Iglesias (Stevenson *et al.*, 1986; Vovides *et al.*, 2004). We consider that *C. vovidesii* forms part of a complex of species in the southern mountains of the Sierra Madre of Chiapas which includes *C. matudae*, and it is also possible that there has been contact with some species within the *C. norstogii* complex (Pérez-Farrera *et al.*, 2004) at some area of this region that has since become fragmented.



**Figure 5.** A, green leaflet articulation of *C. vovidesii*. B, yellow leaflet articulation of *C. matudae*.

The precise locality for *C. vovidesii* has been deliberately omitted in order to avoid decimation of its population by illegal collecting. We have found only four populations of this species in a small geographical area in the Sierra Madre of Chiapas. We recommend the IUCN Red List category (IUCN, 1994) of vulnerable (VU C, 2a), according to Mace & Lande (1991) and Osborne (1995). We recommend this category, in spite of the cycad's presence in a protected area, largely because of its vulnerability to the uncontrolled annual forests fires and the transformation of its habitat to corn and coffee plantations.

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**Figure 6.** A, cylindrical male cone of *C. matudae*. B, conical male cone of *C. vovidesii*.

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## REFERENCES

- Bachem CU, Rojas CR. 1994.** Contribución al estudio ecológico de la vegetación en la región de 'La Fraileasca', Chiapas. Bachelor thesis, Universidad Nacional Autónoma de México, México, D.F.
- Breedlove D. 1981.** Introduction to the Flora of Chiapas. *Flora of Chiapas*. California: Academy of Science Press, 1–35.
- Croat TB, Pérez-Farrera MA. 2000.** A new record of *Anthurium sarukhanianum* (Araceae) to Chiapas, Mexico with additional note on vegetative morphology. *Aroidiana* **24**: 26–30.
- González D, Vovides AP. 2002.** Low intralinesage divergence in the genus *Ceratuzamia* Brongn. (Zamiaceae) detected with nuclear ribosomal DNA ITS and chloroplast DNA *trnL-F* non-coding region. *Systematic Botany* **27**: 654–661.
- IUCN. 1994.** *IUCN red category lists*. Gland, Switzerland: IUCN.
- Long A, Heath M. 1991.** Flora of the Triunfo Biosphere Reserve, Chiapas, Mexico: a preliminary floristic inventory and the plant communities of polygon I. *Anales Del Instituto de Biología de la Universidad Nacional Autónoma de México, Serie Botánica* **62**: 133–172.
- Mace GM, Lande R. 1991.** Assessing extinction threats: towards a reevaluation of IUCN threatened species categories. *Conservation Biology* **5**: 148–157.
- Matuda E. 1950a.** A contribution to our knowledge of the wild flora of Mt. Ovando Chiapas. *American Midland Naturalist* **43**: 195–223.
- Matuda E. 1950b.** A contribution to our knowledge of the wild and cultivated flora of Chiapas. I. Districts Soconusco and Mariscal. *American Midland Naturalist* **44**: 513–616.
- Miranda F. 1957.** Vegetación de la Vertiente del Pacífico de la Sierra Madre de Chiapas. In: Lopez-Sánchez L, ed. *Lecturas Chiapanecas* 6. México: Gobierno Del Estado de Chiapas, 79–101.

- Osborne R. 1995.** The 1991–92 world cycad census and a proposed revision of the threatened species status for cycad taxa. In: Vorster P, ed. *Proceedings of the Third International Conference on Cycad Biology*. Stellenbosch, South Africa: Cycad Society of South Africa, 65–83.
- Pérez-Farrera MA, Quintana-Ascencio PF, Salvatierra-Izaba B, Vovides AP. 2000.** Population dynamic of *Ceratozamia matudai* in el Triunfo Biosphere Reserve, Chiapas, México. *Journal of the Torrey Botanical Society* **127**: 291–299.
- Pérez-Farrera MA, Vovides AP, Hernández-Sandoval L, González D, Martínez M. 2004.** A morphometric analysis of the *Ceratozamia Norstogii* Stevenson complex (Zamiaceae). In: Walters T, Osborne R, eds. *Cycad classification: concepts and recommendations*. Wallingford, UK: Cabi Publisher, 127–136.
- Rzedowski J. 1978.** *Vegetación de México*. Edit Limusa, México, D.F.
- Schutzman B, Vovides AP, Dehgan B. 1988.** Two new species of *Zamia* (Zamiaceae, Cycadales) from southern Mexico. *Botanical Gazette* **149**: 347–360.
- Stevenson D, Sabato S, Vázquez-Torres M. 1986.** A New Species of *Ceratozamia* (Zamiaceae) From Veracruz, Mexico, With Comments on Species Relationships, Habitats, and Vegetative Morphology in *Ceratozamia*. *Brittonia* **38**: 17–26.
- Toledo VM. 1982.** Pleistocene changes of vegetation in tropical México. In: Prance GT, ed. *Biology Diversification in the Tropics*. New York: Columbia University Press, 93–111.
- Vovides AP, Pérez-Farrera MA, González D, Avendaño S. 2004.** Relationships and phylogeography in *Ceratozamia* (Zamiaceae). In: Walters T, Osborne R, eds. *Cycad classification, concepts and recommendations*. Wallingford, UK: CABI, 109–125.