
A New Species of *Ceratozamia* (Zamiaceae) from Querétaro and Hidalgo, Mexico

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ABSTRACT. A new species, *Ceratozamia sabatoi*, is described and illustrated. Its closest affinities are with *C. kuesteriana* from Tamaulipas, but it differs from that species in both cone and leaf morphology. The chromosome number of *Ceratozamia sabatoi* is $2n = 16$, and the karyotype is similar to other species of the genus.

During botanical explorations and ecological impact studies in the area that will be affected by the Zimapán hydro-electric dam project, a small-trunked *Ceratozamia* was found in pine-oak forest by Ricardo Zirahuén, a biologist collaborating with the aforementioned project in the state of Querétaro. This taxon also appears in an adjacent population in mixed oak forest on the Hidalgo side of the border at a similar elevation.

Following further expeditions to both localities to procure live, vegetative, and fertile material to establish at the Jardín Botánico Clavijero (Botanic Garden of the Instituto de Ecología) for observation, it was concluded that this species is new to science. It is compared to *Ceratozamia kuesteriana* Regel, with which it is closely related, but differs in habit, leaf, female cone characteristics, and the light green color of emergent leaves.

Ceratozamia sabatoi Vovides, Vázquez Torres, Schutzman & Iglesias, sp. nov. TYPE: Mexico. Querétaro: 15 Apr. 1991, *A. P. Vovides 1205* female (holotype, XAL). Figure 1.

Truncus globosus ad cylindricum, hypogaeus vel semi-hypogaeus, humilis ad 25 cm altus; cataphylla lanata, triangularia 4.55 cm longa, basi 2.5–3.5 cm lata; folia

pauca, usque 6 pinnate, glabra; petiolus subteres vel cylindricus, 25–45 cm longus, parte infima dilatatus, validis spinis armatus; rachis semiteres in dimidio inferiore paucis spinis armata, supra fere inermis vel inermis, in cuspidem 5–11 mm longem excurrens; foliola subopposita vel alterna, 15–35 juga, remota linearis, 12–25 longa, 1.2–2.4 cm lata, basi cuneata, apicem symmetrice, cuspidata, margine integerrima, 9–14 ($\bar{x} = 12$) nervis; strobilus masculinus lineari-cylindricus 12–20 cm longus, 2–2.4 cm latus; pedunculus tomentosus 6–14 cm longus, 0.8–1 cm latus; strobilus femininus cylindricus 8–10 cm longus, 4–6 cm latus; pedunculus tomentosus 4–8 cm longus, 4–5.5 cm latus; semina 1.5 longa, 1.3 cm lata; $2n = 16$.

Small palmlike plants; trunk partly subterranean, globose, readily producing offshoots, becoming cylindrical with age up to 25 cm long, 17.5 cm diam. protected with persistent leaf bases, dark brown in color. Leaves 2–6, pinnate, spirally arranged forming an open crown, up to 80 cm long, 52 cm wide; petiole and rachis ascending to horizontal, armed with short stout prickles, 0.08–0.4 cm long ($\bar{x} = 0.15$, $n = 40$), petiole tomentose at base. Leaflets 12–136 ($\bar{x} = 69$, $n = 33$ leaves) lanceolate, narrowly obovate to subulate, glabrous, margin entire, subrevolute, apex pungent, base attenuate, dark to light green on adaxial surface, lighter green on abaxial, 9–29 cm long ($\bar{x} = 17$, $n = 47$), 0.7–2.4 cm wide ($\bar{x} = 1.2$, $n = 47$); articulation zone 0.2–0.5 cm wide ($\bar{x} = 0.35$, $n = 43$), venation \pm visible on adaxial surface, more prominent on abaxial, number of veins 9–14 ($\bar{x} = 12$, $n = 20$), distance between veins 0.75–1.4 mm. Microstrobili green when immature becoming light to dark brown at dehiscence, 6.5–23 cm long ($\bar{x} = 15.8$), 1.9–3 cm diam. ($\bar{x} = 2.3$); peduncle tomentose, 1.5–11 cm long ($\bar{x} = 6.3$), 0.5–1 cm diam. ($\bar{x} = 0.7$, all measurements

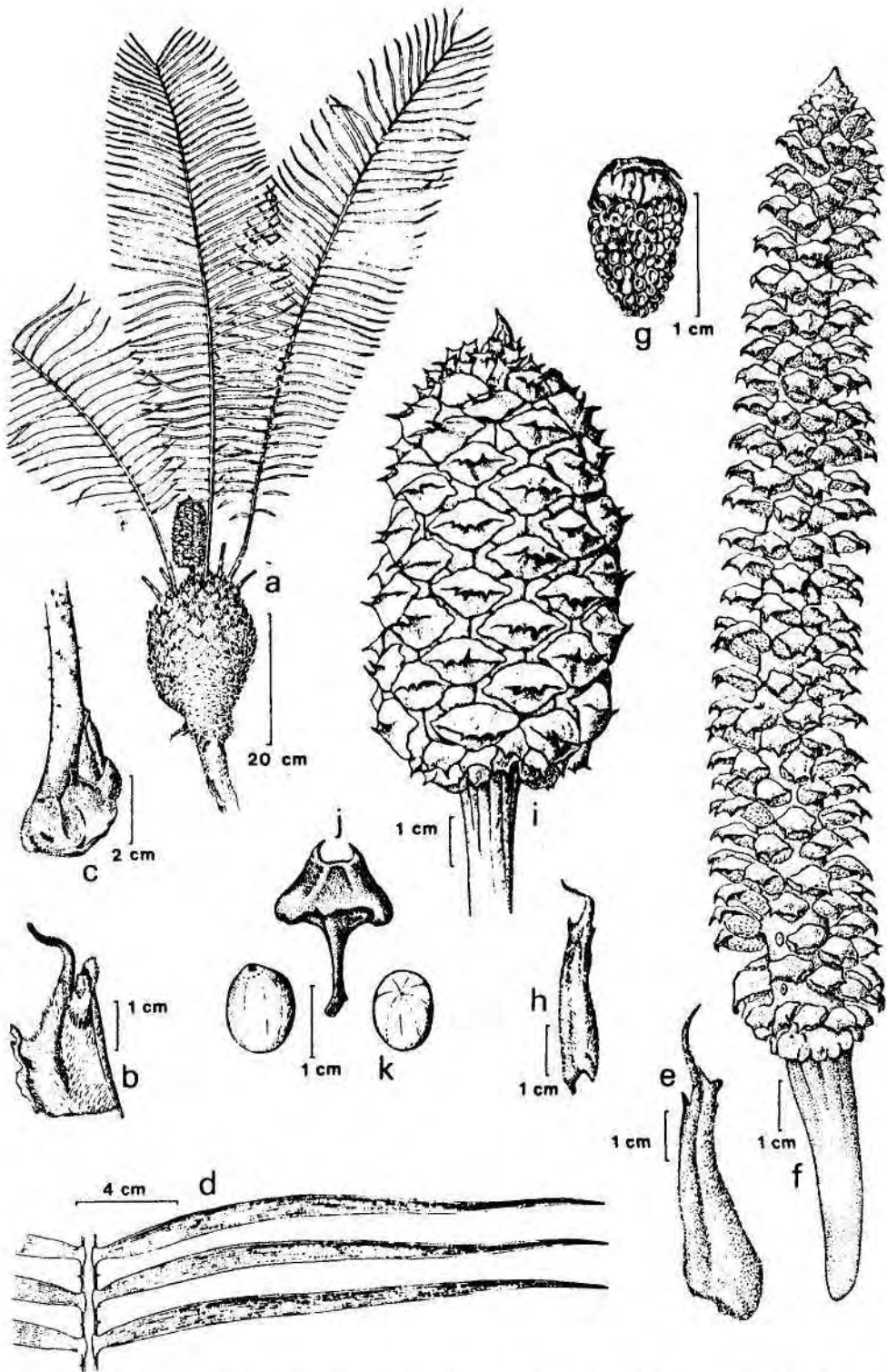


Figure 1. a-k, *Ceratozamia sabatoi* Vovides, Vázquez Torres, Schutzman & Iglesias. —a. Habit of plant. —b. Leaf cataphyll. —c. Base of petiole. —d. Detail of leaflets and rachis. —e. Male cone cataphyll. —f. Male cone at dehiscence. —g. Microsporophyll. —h. Female cone cataphyll. —i. Mature female cone. —j. Megasporophyll. —k. Seeds.

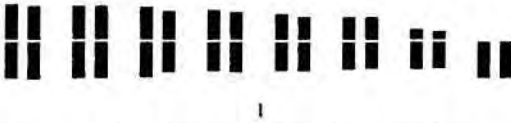


Figure 2. Diploid idiogram of *Ceratozamia sabatoi* ($2n = 16$), bar = 2 μm .

$n = 6$); microsporophylls numerous, spirally arranged forming apparently vertical rows, cuneiform, bicornate at distal end, fertile portion covering $\frac{1}{2}$ – $\frac{2}{3}$ of abaxial surface excluding horns and stalk, 0.9–1.4 cm long ($\bar{x} = 1.1$), 0.4–0.7 cm wide ($\bar{x} = 0.6$, $n = 6$); microsporangia numerous in sori of 2 to 3, dehiscence by longitudinal slit, 0.9–1.3 mm diam. ($\bar{x} = 1.1$, $n = 12$). Megastrobili cylindrical to barrel-shaped slightly tapering toward apex, light blue-green when immature, turning green to light blue-brown at maturity, 6.0–12 cm long ($\bar{x} = 9.5$), 3.4–5.6 cm diam. ($\bar{x} = 4.8$); peduncle tomentose, 2.0–10 cm long ($\bar{x} = 5.4$), 0.6–1.3 cm diam. ($\bar{x} = 0.8$); megasporophylls numerous, spirally arranged forming apparently vertical rows, cuneiform-peltate, distal ends hexagonal, thickened, bicornate, with reddish tomentum near horns, 1.7–2.6 cm long ($\bar{x} = 2.1$), 1.1–2.8 cm wide ($\bar{x} = 1.7$, all measurements $n = 7$). Seeds ovate variably angulate, sarcotesta creamy-white when immature becoming blue-green to light brown when mature, sclerotesta light beige, smooth, 8–10 visible ridges radiating from micropyle, 1.3–1.9 cm long ($\bar{x} = 1.5$), 1.1–1.4 cm diam. ($\bar{x} = 1.3$, $n = 6$). Chromosome number $2n = 16$.

We assign the specific epithet in honor of the late Sergio Sabato, distinguished professor at the University of Naples, Italy, for his outstanding and prolific fieldwork and experimental biology on neotropical Zamiaceae.

Paratypes. MEXICO. **Querétaro:** 15 Apr. 1991, A. P. Vovides, K. Norstog & P. Fawcett 1200, 1201, 1202, 1204, all ♀, 1190, 1191, 1192, 1194 all ♂ (XAL). **Hidalgo:** 12 Feb. 1991, A. P. Vovides, M. Vázquez T. & C. Iglesias 1156, 1157, 1158, 1159, 1160 all ♀, 1161, 1162, 1163, 1164, 1165, 1166, 1168, 1169, 1170, 1171, 1172, 1173, 1175, 1176, 1177, 1178, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186 all ♂ (XAL).

The following key permits the separation of *Ceratozamia sabatoi* from *C. kuesteriana* and *C. microstrobila*.

DIAGNOSTIC KEY

- 1a. Median leaflet width greater than 2.8 cm, persistent leaf bases light brown, tightly appressed to trunk *C. microstrobila*
- 1b. Median leaflet width less than 2.8 cm, persistent leaf bases dark brown, not appressed to trunk
 - 2a. Petiole and rachis coppery in adult leaves; leaflets falcate to subfalcate, linear-lanceolate; veins 6–9; megastrobili reddish-brown to dark green, longer than 13cm *C. kuesteriana*
 - 2b. Petiole and rachis light to dark green in adult leaves; leaflets not falcate to subfalcate, not linear-lanceolate; veins 9–14; megastrobili blue-green to blue-brown, less than 13cm long *C. sabatoi*

CHROMOSOMAL STUDIES

The chromosome number and karyotype were determined from three established specimens held at the Jardín Botánico Fco. J. Clavijero under the accession numbers: 91-028, 91-040, 91-041 and vouchers deposited at (XAL). The root tip mitosis technique was used described by Vovides (1983) and chromosome classification based on centromere position that of Levan et al. (1964) modified by Schlarbaum and Tsuchiya (1984). The diploid idiogram (Fig. 2) was constructed by taking the average arm lengths of the best three metaphase cells examined (Fig. 3). Arm lengths, total chromosome length, chromosome index (short arm divided by long arm), and symmetry index (length of longest pair divided by length of shortest pair) were computed using the average arm lengths from the three metaphase cells (Table 1). The karyotype shows 11 median region (m) chromosomes, 1 submedian (sm) chromosome, 1 subterminal region (st) chromosome, and 2 terminal point (T) chromosomes. Satellite number and position vary with cells observed and a maximum of 5 satellites were recorded, but not considered in the calculations.

HABITAT

The vegetation at the Querétaro locality is mainly pine-oak forest dominated by *Pinus teocote* Schlechtendal & Chamberlain, *Quercus crassifolia* Humboldt & Bonpland, *Q. macrophylla* Martius & Galeotti, *Q. germana* Chamberlain & Schlechtendal, and *Q. xalapensis* Humboldt & Bonpland on reddish clay (laterite) soils. The vegetation of the Hidalgo locality, a mixed oak forest, appears much richer due to higher rainfall. The dominant tree species are; *Arbutus xalapensis* Humboldt, Bonpland & Kunth, *Buddleja cordata* Humboldt, Bonpland & Kunth, *Carya ovata* (Miller) K. Koch, *Litsea glaucescens* Humboldt, Bonpland & Kunth, *Meliosma alba* (Schlechtendal) Walpers, *Persea* sp., *Prunus serotina* Ehrenberg, *Quercus germana* Chamberlain & Schlechtendal, *Q. sartorii* Liebmann, *Q. polymorpha* Schlechtendal & Chamberlain, and *Q.*



Figure 3. Chromosomes of *Ceratozamia sabatoi* at mitotic metaphase, bar = 2 μ m.

xalapensis Humboldt & Bonpland. The soil is a dark humus-rich clay on limestone.

DISCUSSION

Precise information on localities has been purposely omitted in order to discourage indiscriminate commercial collecting, which could lead to the extinction of this endangered species.

Even though some vegetative characteristics, especially the leaves, show on occasion morphological similarities between *Ceratozamia kuesteriana* and *C. sabatoi*, the consistent differences in cones, emergent leaves, seeds, and habitat lead us to consider the two taxa as separate species. Geographically speaking, several species are found in the areas between *C. kuesteriana* and *C. sabatoi*, including *C. zaragozae* Medellín, *C. hidae* Landry & Wilson, *C. microstrobila* Vovides & Rees, and *C. mexicana* var. *robusta* (Miquel) Dyer, species whose populations are well delimited. *Ceratozamia sabatoi* occurs amongst low shrubs in oak forests and mixed oak-pine forests on volcanic soils in relatively dry habitats; *C. kuesteriana*, however, is found in much wetter cloud-forests on karst topography.

The chromosome count and karyotype are consistent with that reported for the genus ($2n = 16$) by Marchant (1968), Vovides (1983; 1985) and Moretti (1990). The karyotype is nearly typical for the genus *Ceratozamia* ($12m + 2sm + 2T$), which appears to be stable. The *msm* and *st* chromosomes fall into these categories only by 0.03 and 0.01 μ m respectively and, considering the considerable length of cycad chromosomes, these discrepancies are

TABLE 1. Karyotypic data at metaphase in root-tip mitoses of *Ceratozamia sabatoi* (mean of three metaphase cells). *m* = median, *msm* = median-submedian, *sm* = submedian, *st* = subterminal, *T* = terminal.

Chromosome pair	Arm length (μ m)			Index (S/L)	<i>r</i> value	Centromere position
	Long (L)	Short (S)	Total			
1	6.67	6.62	13.29	0.99	1.01	<i>m</i>
	6.92	6.10	13.02	0.88	1.13	<i>m</i>
2	6.78	6.15	12.93	0.91	1.10	<i>m</i>
	6.67	6.15	12.82	0.92	1.08	<i>m</i>
3	6.61	5.96	12.57	0.90	1.11	<i>m</i>
	5.67	5.30	10.97	0.93	1.07	<i>m</i>
4	5.53	5.41	10.94	0.98	1.02	<i>m</i>
	5.56	5.15	10.71	0.93	1.08	<i>m</i>
5	5.43	4.78	10.21	0.88	1.14	<i>m</i>
	5.54	4.18	9.72	0.75	1.33	<i>msm</i>
6	5.14	4.24	9.38	0.82	1.21	<i>m</i>
	4.92	4.15	9.07	0.84	1.19	<i>m</i>
7	5.14	1.96	7.10	0.38	2.62	<i>sm</i>
	4.99	1.66	6.65	0.33	3.01	<i>st</i>
8	6.64	0.00	6.64	0.00	0.00	<i>T</i>
	6.71	0.00	6.71	0.00	0.00	<i>T</i>

Symmetry index = 0.51. Average chromosome index = 0.72. Total chromosome length = 162.73.

probably due to differential contraction at metaphase. The number and position of satellites varies between the species (Vovides, 1983). Two satellites have been reported by Vovides (1985) in *C. kuesteriana* and *C. sabatoi* has five.

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Literature Cited

Levan, A., K. Fredga & A. A. Sandberg. 1964. Nomenclature for centromeric position on chromosomes. *Hereditas* 52: 201-220.
 Marchant, C. J. 1968. Chromosome patterns and nuclear phenomena in the cycad families Stangeriaceae and Zamiaceae. *Chromosoma (Berl.)* 24: 100-134.
 Moretti, A. 1990. Karyotypic data on north and central American Zamiaceae (Cycadales) and their phylogenetic implications. *Amer. J. Bot.* 77: 1016-1029.
 Schlarbaum, S. E. & T. Tsuchiya. 1984. The chromosomes of *Cunninghamia konishi*, *C. lanceolata*,

-
- and *Taiwania cryptomerioides* (Taxodiaceae). *Pl. Syst. Evol.* 145: 169-181.
- Vovides, A. P. 1983. Systematic studies on the Mexican Zamiaceae I. Chromosome numbers and karyotypes. *Amer. J. Bot.* 70: 1002-1006.
- . 1985. Systematic studies on Mexican Zamiaceae II. Additional notes on *Ceratozamia kuesteriana* from Tamaulipas, Mexico. *Brittonia* 37: 226-231.

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