A new species of Ceratozamia (Zamiaceae) from Oaxaca, Mexico with comments on habitat and relationships

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Ceratozamia chimalapensis sp. nov. is described and illustrated. It is related to C. mirandae Vovides, Pérez-Farrera & Iglesias from Chiapas, but differs in trunk and peduncle size as well as in diameter of both megastrobili and microstrobili. Petiole, megasporophyll and indument colour also differ from that of C. mirandae.

Ceratozamia chimalapensis forms part of the C. norstogii D.W.Stev. species complex, a group of ceratozamias with narrow leaflets growing in the herbaceous layer of oak forests in southern Mexico. These forests were severely affected by forest fires during 1998 and we recommend an IUCN Red List Category of CR B.1. Speciation in Ceratozamia has been discussed in the light of floristic refugia. © 2008 The Linnean Society of London, Botanical Journal of the Linnean Society, 2008, 157, 169–175.


INTRODUCTION

During a revision of the genus Ceratozamia Brongn. for south-east Mexico, with the aim of solving the identity of populations within the C. norstogii D.W.Stev. species complex, we came upon a herbarium voucher from south-east Oaxaca misidentified as C. matudae Lundell. After observation of the plants in habitat, and cultivating several specimens of this species ex situ – together with its congeners and especially with C. matudae – at the School of Biology at the Universidad de Ciencias y Artes de Chiapas and the Botanic Garden (Fco. J. Clavijero, Instituto de Ecología, Xalapa), respectively, for 5 years and, upon having observed leaf, leaflet, trunk and cone morphology to discard plasticity, we came to the conclusion that it is new to science.

DESCRIPTION

CERATOZAMIA CHIMALAPENSI PÉREZ-FARRERA & VOVIDES SP. NOV. (Figs 1–4)

Diagnosis: Plantae 20–100 cm altae; tronco cylindrico, cataphylliis lanatis, triangularibus, stipulatis; foliis pinnatis, petiolo 38–80 cm longo, aculeatissimo, rhachidi 48–150 cm longa, parce aculeata, folioliis alternatis, 29–68 jugatis, linearibus; strobilis masculinis 28–33 cm longis, linear–cylindricis, pedunculo c. 7 cm longo, tomentoso, strobilis femineis 35–40 cm longis, erectis, pedunculo 7–11 cm longo, tomentoso; seminibus 2.5–3 cm longis.
Type: MÉXICO, OAXACA, Chimalapa. 21 i. 2002 MA. Pérez-Farrera 2622 female (Holotype, HEM; Isotypes XAL; MEXU; MO).

Description: Medium-sized plant, TRUNK cylindrical, semihypogeal becoming arborescent with age, sparsely branching (up to two branches), erect, 20–100 cm long, 17.8–33.1 cm in diameter, armed with light-brown persistent leaf bases in the upper part of the trunk. CATAPHyllS triangular, stipulate, silvery sericeous in the middle and apical part, 4.5–7.5 cm long, 2.6–4 cm wide. LEAVES 7–22, ascending remaining erect to slightly descending near apical portion, pinnate, forming an open crown 34–244 cm long, 45–122 cm wide, reddish brown, white tomentose when emergent, dark green glabrous when mature, vernation erect, seedling eophylls 4. PETIOLE erect, light orange to straw coloured, terete, 38–80 cm long, 0.9–1.6 cm diameter, armed with stout slightly arched prickles being more numerous towards the base. RACHIS erect, semiterete, 48–150 cm long, armed with few prickles. LEAFLETs linear–lanceolate, flat in section, variable from non-falcate to falcate to subfalcate, 29–68 pares, opposite at proximal and median part of leaf, subopposite towards distal portion of leaf; margins entire, subrevolute, brilliant dark green on adaxial surface, light green on abaxial surface, 27–46 cm long, 1.3–2 cm wide, venation visible on abaxial surface, 12–16 veins, distance between veins 0.97–1.70 mm; articulations green rarely slightly light yellow to copper, 0.55–0.87 cm wide. MICROSTROBILI conical, erect, light to olive green at emergence, creamy to light yellow when mature, 28–33 cm long, 3.1–5 cm diameter;

Figure 1. Ceratozamia chimalapensis. A, habit of plant. B, detail of petiole bases. C, detail of leaf and petiole.
peduncle tomentose, light brown at emergence turning brown at maturity, 6.8–7 cm long, 1.7–3 cm diameter.

MICROSPOROPHYLLS indeterminate, cuneiform, bicornate at distal end, inserted spirally on cone axis forming apparent vertical rows, red tomentulose, fertile portion covering one-half to two-thirds of the abaxial surface excluding the horns, 1.2–1.9 cm long, 0.64–0.98 cm wide; MICROSPORANGIA indefinite in sori of 3–4, dehiscent by a longitudinal slit. MEGASTROBILI cylindrical or barrel shaped, erect when emergent, descending when mature, blue–green at emergence, dark brown when mature, 35–40 cm long, 7.3–10.6 cm diameter at median portion; peduncle slightly tomentose, 7–11 cm long, 1.92–1.94 cm diameter; MEGASPOROPHYLLS indefinite, spirally inserted on cone axis forming apparent vertical rows, distal face hexagonal, bicornate, with metallic-blue epidermal colouring on the margins of the lobes partly covered with greyish tomentulum extending to about one-third of the distance towards the horns 5.2–6.1 cm long, 1.9–2.5 cm wide. SEED ovate, sarcotesta white when immature, light yellow to light cream – beige upon maturity, sclerotesta smooth with 7–10 visible rays radiating from the micropyle, 2.5–2.9 cm long, 1.5–1.7 cm in diameter. Chromosome number 2n = 16.
The closest affinity of the new species is with Ceratozamia mirandae Vovides, Pérez-Farrera & Iglesias.

**Etymology**: We assign the specific epithet in honour of the Chimalapas wilderness, in recognition of its biological richness and the floristic diversity of Oaxaca State.

The local name given to this plant by the Zoque Indians is Mazacopa (the name means ball head, alluding to the spherical appearance of young trunks). This was widely used as a food: the sweet sarcotesta is eaten and starch is extracted from pre-treated seeds to make flour. By grinding up the seed, it was also used as a rodenticide and, by mixing honey with the ground seeds, it was also used as an insecticide. Cycads are known to be toxic to both animals and humans (Norstog & Nicholls, 1997).


**HABITAT DESCRIPTION**

The locality of this species is in the extreme western portion of the Sierra Madre de Chiapas massif, commonly known as the ‘Sierra Atravesada’, consisting partially of Jurassic and Cenozoic deposits, with the latter comprising silica pyroclastic bodies (Ferrusquía-Villafranca, 1993). The vegetation type is oak forest ‘Bosque de Quercus’ according to the Rzedowski (1978) classification and lies within the southern limits of Cenozoic ‘Arc’ floristic refugium of Wendt (1987). Dominant tree species are mainly: Quercus sp., Pinus oocarpa Schiede, Liquidambar styraciflua L., Nectandra sp., Calliandra houstoniana Standl., Bursera simaruba Sarg., Cecropia obtusifolia Bertol. Common species in the herbaceous layer are: Lasiacis nigra Davidse, Begonia heracleifolia Cham. & Schltdl., Elaphoglossum latifolium (Sw.) J.Sm. and Euphorbia scabrella Boiss. The soil type common in this mountainous zone is mainly clayish and at times slightly sandy to stony with little superficial humus. The topography is relatively steep, with slopes of up to 40° and an altitudinal range of 270–1000 m. This area lies within the Chimalapa wilderness of Oaxaca and is noted for its high floristic and faunistic diversity (MacDougall, 1971; Rodríguez & Asquith, 2004).

**DISCUSSION**

This species has been confused with Ceratozamia matudae Lundell (Moretti, Sabato & Vázquez Torres, 1980; Stevenson, Sabato & Vázquez Torres, 1986) involving a collection by Hernández-Xolocotzi & A. J. Sharp 1277 (MEXU). In his book The Cycads’, Whitelock (2002) also confuses C. chimalapensis with C. mirandae, an endemic of Chiapas (plate 63, 63) and on p. 68 where he mistakenly situates C. mirandae in the Chimalapa region of Oaxaca. This confusion is understandable as C. chimalapensis does...
Vegetative key separating species of Ceratozamia from southern Mexico:

1a. Leaflets arranged spirally, rachis twisted ............................................................... C. norstogii
1b. Leaflets not arranged spirally, rachis straight
2a. Leaflets canaliculate ............................................................................................. C. mirandae
2b. Leaflets not canaliculate
3a. Articulation between leaflet and rachis yellow ..................................................... C. matudae
3b. Articulation between leaflet and rachis green
4a. Leaflets more than 74 pairs .................................................................................. C. vovidesii
4b. leaflets less than 74 pairs
5a. Leaflets not falcate ............................................................................................... C. alvarezii
5b. Leaflets mainly falcate ....................................................................................... C. chimalapensis

Figure 4. Comparison of rachis and leaflet articulation colouring of A, Ceratozamia chimalapensis; B, Ceratozamia mirandae. Note slight copper-yellowish rachis and articulations in C. chimalapensis.
share affinity with C. mirandae and C. matudae. However, population studies of C. matudae in Chiapas by Pérez-Farrera et al. (2000) involving detailed observations, as well as comparisons of habits and habitats with those of the taxon at the Oaxaca locality mentioned by Stevenson et al. (1986), Moretti et al. (1980) and Whitelock (2002), enabled us to recognize C. chimalapensis as a new species. Two characters that are shared by C. matudae are the flat or non-canaliculate leaflets and, on rare occasions, a light-yellow to copper colouring of the leaflet articulations and rachis, but there are great differences in megastobinus morphology. In C. matudae it is spherical to barrel shaped, olive green and with an extremely long peduncle, whereas in C. chimalapensis it is cylindrical, blue–green with a shorter peduncle. Ceratozamia chimalapensis has thicker and shorter male cone peduncles, whereas in C. mirandae they are thinner and longer. The opposite is true of the megastrobilus peduncles, which are thinner and longer in C. chimalapensis and thicker and shorter in C. mirandae. The megasporophyll colour in C. chimalapensis is blue–green with greyish–tomentulose margins, and in C. mirandae it is light green with glabrous to beige–tomentulose margins. The new species also shares trunk similarity with C. mirandae (arborescent and branched), as well as long and narrow subfalcate leaflets, but in C. mirandae the leaflets are canaliculated, whereas in the new species they are flat in section. Owing to the leaflet characteristics presented by C. chimalapensis, we include it in the second group of ceratozamias according to Stevenson et al. (1986) and Vovides et al. (2004) that includes C. norstogii.

It is interesting to note that Ceratozamia spp. in southern and south-east Mexico are associated with refugia that contain floristic elements of great age (Toledo, 1982; Wendt, 1987). These palaeoendemic cycads are isolated taxa, whose historical distribution probably covered larger areas but have since been reduced owing to environmental changes and, in recent years to human activity. González & Vovides (2002) and Vovides et al. (2004) hypothesize that the genus probably originated in southern Mexico, held out in floristic refugia during the Pleistocene glaciations, and has since expanded from these refugia, during post-Pleistocene climate warming, to occupy niches especially north of the Mexican Transverse Volcanic Mountain Range. This pattern is reflected in the Mexican cycad genus Dioon the probable speciation patterns of which are related to historical events and posterior expansion and/or vicariance processes that mainly occurred during the early Cenozoic (Moretti et al., 1993). Another case study is given by Dioon edule and Dioon angustifolium (González-Astorga et al. 2003a; González-Astorga, Vovides & Iglesias, 2003b; González-Astorga et al. 2005), wherein the genetic bottlenecking and founder effect have determined the formation of the latter species, also reflected in the leaflet morphology of D. angustifolium. In the case of the widely distributed Zamia loddigesii, a correlation was found between genetic variation and latitude in four of its populations (González-Astorga et al., 2006).

During 1998 and 2002, this population, then under study, suffered intense forest fires that affected approximately 482 000 ha of tropical forest. This was the result of the driest spring in Mexico since 1941, caused by the ‘El Niño’ effect, that added an additional 24% to the region’s average annual net carbon emission (Cairns et al., 1999; Mora & Hernández-Cárdenas, 1999). These fires resulted in a high seedling mortality, forcing us to discontinue monitoring the population. Because we have only localized one population in the Chimalapa region of Oaxaca, precise locality information has been purposely omitted in order to discourage illegal collection of this rare and endangered species. We therefore consider it to be endangered owing to the rapid transformation of its habitat into pastureland and coffee plantations. Because of the small population size and highly restricted distribution of C. chimalapensis, we propose the IUCN Red List Category of CR B.1. (IUCN, 2005).

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