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Magnolia vargasiana (Magnoliaceae), a new Andean species and a key to Ecuadorian species of subsection *Talauma*, with notes on its pollination biology

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Introduction

Magnoliaceae Jussieu (1789: 280) consist of ca. 330 species worldwide, nearly half of them in the New World (Vázquez-García *et al.* 2014). There is no agreement on the internal classification, including the number of sections (0–11), genera (1–13), subgenera (0–9) and subfamilies (0–2) (Figlar & Nooteboom 2004; Xia *et al.* 2008, Romanov & Dilcher 2013) and despite various phylogenetic studies of Magnoliaceae in the last two decades, classification of the family has not reached a consensus (Qiu *et al.* 1993, 1995; Kim *et al.* 2001; Azuma *et al.* 2001, Li & Conran 2003, Nie *et al.* 2008, Kim & Suh 2013). Here we follow the classification of Figlar & Nooteboom (2004).

Neotropical Magnoliaceae Jussieu are represented by a single genus, *Magnolia* Linnaeus (1753: 535), and 129 recognized species (Vázquez-García *et al.* 2014), comprising three sections: 1) sect. *Macrophylla* Figlar & Nooteboom (2004: 92; three species south of the Tropic of Cancer in México); 2) sect. *Magnolia* (23 species in México and Central America, two in eastern United States and one in the Caribbean); and 3) sect. *Talauma* (Jussieu 1789: 281) Baillon (1866: 66; 103 species), which is further subdivided in three subsections: a) subsect. *Cubenses* Imkhanitskaya (1991: 60; ten species confined to the Caribbean region); b) subsect. *Dugandiodendron* (Lozano, 1975: 33) Figlar & Nooteboom (2004: 90; 21 species confined to northern South America in the Andes and the Guyana Shield, seven of them occurring in Ecuador); and c) subsection *Talauma* (72 species distributed from 20 degrees of northern latitude in western and eastern México to 24 degrees southern latitude, just south of the Tropic of Capricorn, in Paraná, Brazil and elevations from near sea level to 2800 m) the largest subsection in the family. Lozano-Contreras's work included 31 Neotropical species in subsect. *Talauma*, 20 of which he described (Lozano-Contreras 1983, 1994), but the number of species has more than doubled in the last five years (Serna *et al.* 2009; Dillon & Sánchez-Vega 2009, Vázquez-García *et al.* 2012a, 2012b, 2013a, 2013b, 2013c, 2013d, 2014; Marcelo-Peña & Arroyo 2013, Arroyo & Pérez 2013, Arroyo *et al.* 2013, Arroyo 2014). Additional (ca. 28) undetermined Neotropical species of *Magnolia* are currently under study by various authors.

Magnoliaceae in Ecuador display a high level of endemism (78%), particularly in the Cordillera del Condor and Amazonia, and to a lesser extent in the Andes and northern coast. It is noteworthy that the Zamora Chinchipe Province currently with seven species of *Magnolia* is the richest Neotropical area for *Magnolia*, and possibly worldwide too, and therefore the area should be considered a *Magnolia* hotspot for conservation (Vázquez-García *et al*. 2014).

There are 18 recognized species of *Magnolia* in Ecuador (Table 1), all belonging to sect. *Talauma* (authors of all species names provided in Table 1): six belong to subsect. *Dugandiodendron* (five from Cordillera del Condor: *M. bankardiorum*, *M. lozanoi*, *M. jaenensis*. *M. shuarorum* and *M. yantzazana*; and one from the Chocó region: *M. striatifolium*); and twelve species from subsect. *Talauma* (five from the Amazonian lowlands: *M. equatorialis*, *M. kichuana*, *M. neillii*, *M. pastazaensis,* and *M. rimachii*; two from the Chocó region: *M. canandeana* and *M. dixonii*; two from the southern Cordillera Oriental: *M. palandana, M. zamorana*; one from Cordillera del Cóndor, *M. crassifolia*; and two from the central Cordillera Oriental: *M. llanganatensis* and *M. vargasiana*, here proposed as new). There are five other undetermined Ecuadorian species of *Magnolia* subsection *Talauma* currently under study (Table 1).

During vegetation sampling of several 0.25 ha plots in May 2014 with students from the University of Alabama,

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an unusual tree was discovered with sub-orbicular leaves with a cordate base, not matching any known species of *Magnolia*. The typical stipule scar along the adaxial side of the petiole confirmed that the species corresponds to subsection *Talauma*, and soon after obtaining flowering material of these extremely geographically restricted specimens from the Cordillera Llanganates in the central Cordillera Oriental we were certain that we were dealing with a new species, described below as *Magnolia vargasiana*.

Magnolia vargasiana A.Vázquez & D.A.Neill, *sp. nov.*, Figs. 1–3

Type:—ECUADOR. Tungurahua: near the Pastaza boundary, Cordillera Llanganates, ca. 7 km (straight line) northeast of Topo, east of Río Zuñac, 01°22'06" S, 78°08'59" W, 2000 m, 23 August 2014 (fl bud, fl), *Vázquez-García 10118* with D. Neill, A. Rosillo and the Recalde family (holotype: ECUAMZ!, isotypes: IBUG!, MO!, QCNE!).

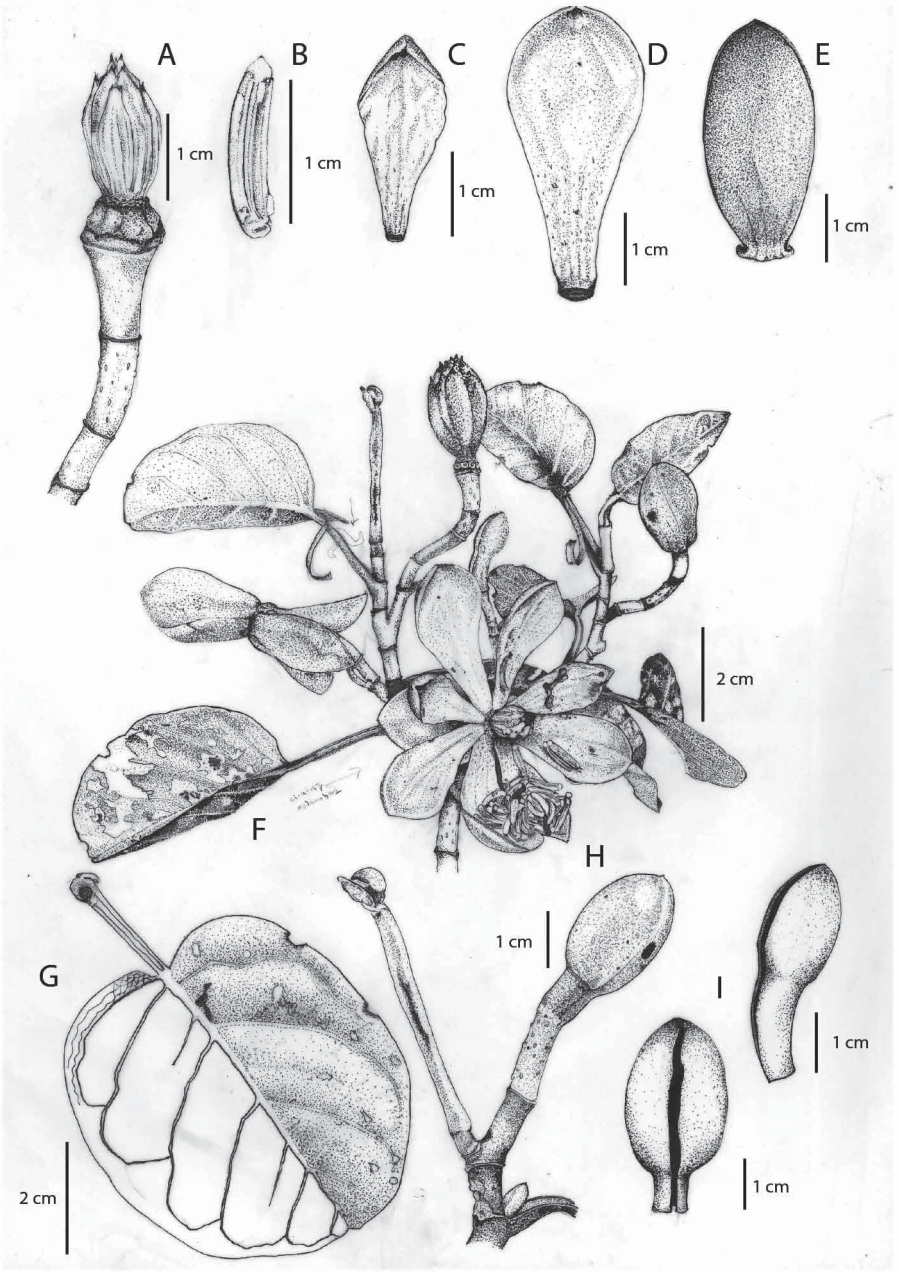

FIGURE 1. *Magnolia vargasiana.* A. Gynoecium. B. Stamen. C. Inner petal. D. Outer petal. E. Sepal. F. Flowering branch. G. Leaf. H. Flowering bud. I. Hypsophylls. Drawing by Efrén Merino-Santi, Kichuan artist and student at Universidad Estatal Amazónica, based on *Merino-Santi et al. s.n*.

Diagnosis: *Magnolia vargasiana* shares with *Magnolia kichuana* the sub-orbicular leaves and a similar number of carpels, but it differs from the latter in having a narrower leaf 7.50–11.0 vs. 13.3–22.0 cm; smaller obovate-spathulate

outer petals 3.5–3.8 vs. narrowly oblanceolate (4.3–)5.8–8.2 cm long; and a greater number of stamens 50–54 vs. 38–42(–50) (Table 2).

Trees 11–26 m tall, 20–50 cm dbh, first branches at 6–10 m; bark longitudinally and narrowly striate with lenticels, apparently smooth, greyish; terminal twig internodes 4.0–8.0(–10.0) × 2.8–4.0 mm, lenticellate, glabrous; petioles 4.0–6.50 × 0.2–0.3 cm, stipules c. 3.4 cm long, covering the entire length of petiole; mature leaf blades 6.0–10.5 × 7.5–11.0, suborbicular, broader in the lower half, rarely wider than long, subcordate to cordate at the base, obtuse or rarely emarginate at the apex, coriaceous, glabrous, 6–7 lateral veins per side; hypsophylls (2.0–)3.5–2.8 × 2.5–3 cm, peduncle 1.0–1.8 cm, flower buds ellipsoidal 1.5–2.8 × 1.5–1.7 cm, glabrous; open flower 7.0–7.5 cm in diameter; sepals elliptic 3.6–3.7 × 1.8–2.0 cm, adaxially creamy white, abaxially dark grayish at the base and axis, fading to creamy white at the margins; petals 8, obovate to spathulate and concave, unequal in size, 2.7–3.8 × 0.8–2.0 cm, creamy white; stamens 50–54, 1.20 × 0.15 cm, creamy white; gynoecium ellipsoid, 1.5–1.7 × 0.7–0.8 cm, pale yellowish green; carpels 10, stylar tips 1.5 mm long, black. Fruit and seeds unknown.

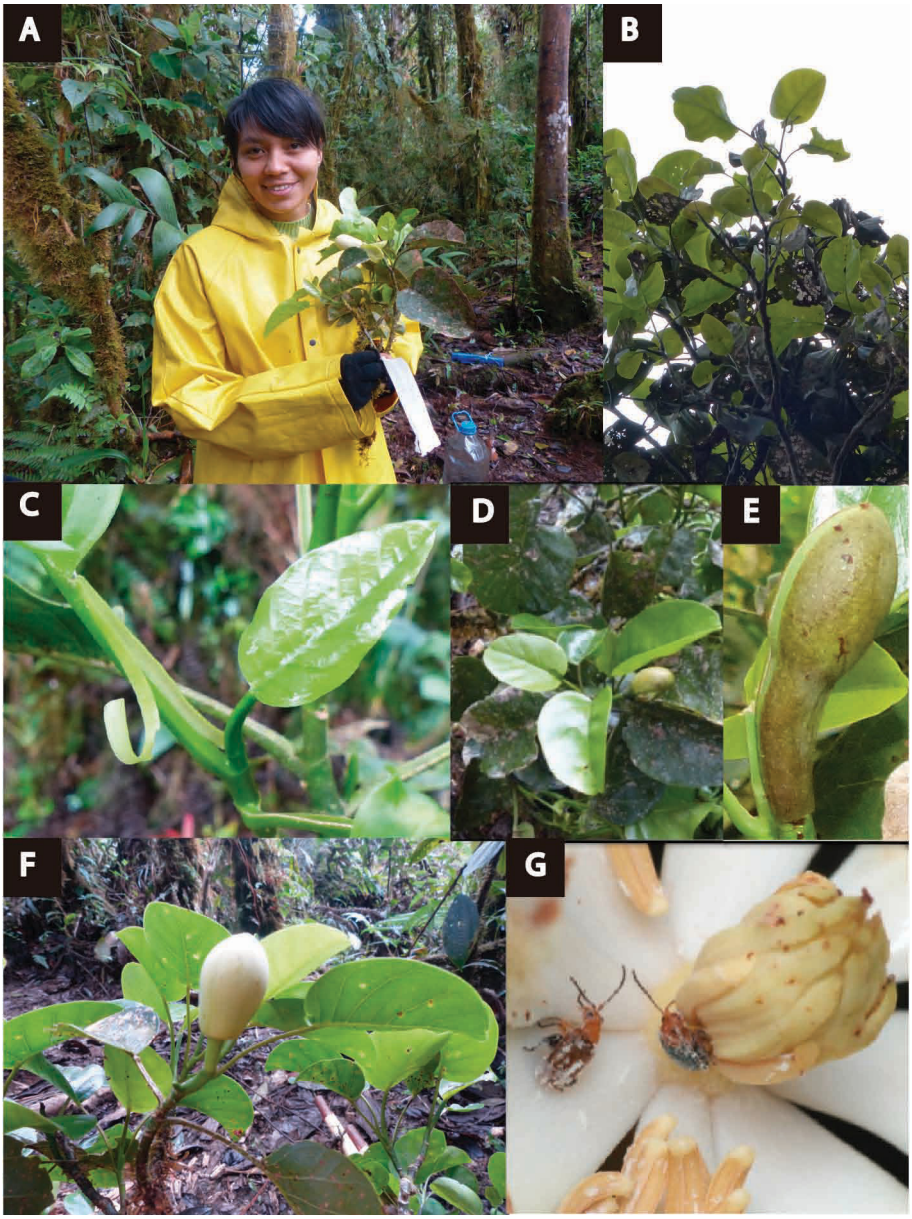

FIGURE 2. *Magnolia vargasiana* A. Yajaira Malucín, student at Universidad Estatal Amazónica, holding a flower bud, with sepals all the way down in day one (male phase) at 9:16 hrs, where flea beetles had just overnighted and are about to leave the flower in the afternoon. With dense "bosque siempreverde montano" in the background. B. Foliage. C. Detaching stipule. D. Branch with flower bud including second hypsophyll. E. First hypsophyll. F. Flower bud in day 0 (0D, female phase), without hypsophylls. G. Flea beetles (Tribe Alticini, Chrysomelidae) covered with pollen. (Photographs: B, C & E by Fausto Recalde, from the holotype; A, D, F & G by Lou Jost, from *Merino-Santi et al. s.n.,* ECUAMZ, IBUG).

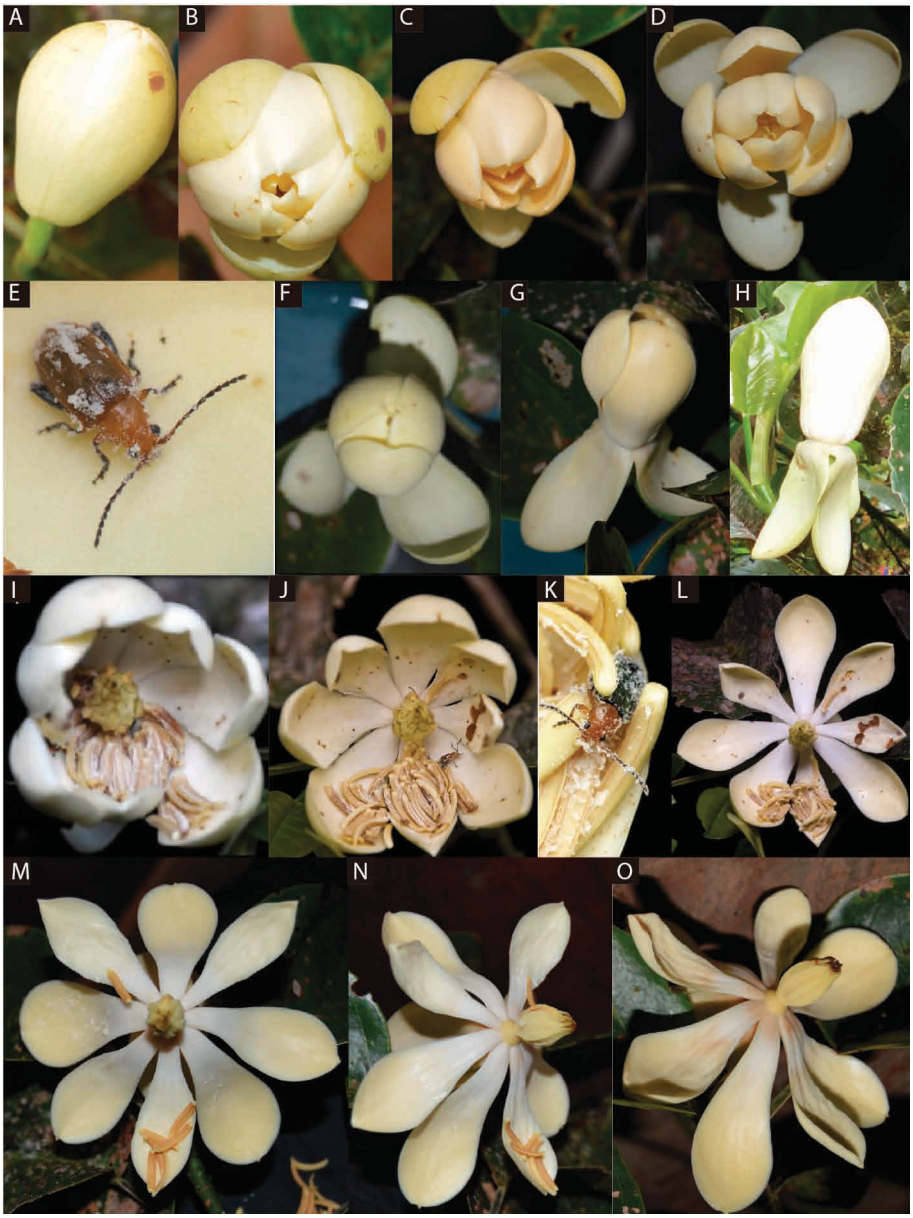

FIGURE 3. *Magnolia vargasiana*. Flowering timing. A. Day zero (0D, female phase), 16:49 hrs. B. 0D 17:16 hrs. C. 0D 17:28 hrs. D. 0D, 18:00–19:58 hrs. E. Flea beetle, orange brownish (Tribe Alticini, Chrysomelidae). F. 0D 21:04 hrs. G. Day one (1D, male phase) 4:23 hrs. H. 1D, ca. 9:13 hrs. I. 1D, 14.05 hrs J. 1D, 14:25 hrs. K. Flea beetle, bright green. L: 1D, 14:55 hrs. M. 1D, 18:27 hrs. N. 1D, 18:27 hrs. (side view). O. 2D, 2:43–6.19 hrs. (Photographs: A–D, F–G, & M–O by Antonio Vázquez, from *Vázquez-García et al. 10131*; E & I–K by Lou Jost, basaed on *Merino s.n.,* ECUAMZ, IBUG; and H by Efrén Merino, based on *Merino-Santi s.n.,* ECUAMZ, IBUG).

Distribution and ecology:—*Magnolia vargasiana* is endemic to the Cordillera de los Llanganates, Tungurahua (Ecuador) and is thus far only known from the type locality, consisting of two trees > 10 cm dbh within a permanent forest inventory plot of 0.25 ha at 2000 m elevation in the Río Zuñac Reserve (Zuñac Plot 2). The Río Zuñac Reserve is a privately held conservation area privately owned by an Ecuadorian non-government organization, the EcoMinga Fundation. The plot itself is about 1 km outside the boundary of Llanganates National Park, located on a steep mountain ridge above the canyon of the upper Rio Zuñac; this portion of the Llanganates is also known as the Cordillera Abitagua. The climate is perhumid with annual rainfall greater than 4000 mm (Ministerio del Ambiente, 2012). Vegetation is described as being a dense cloud forest, with about 800 trees ≥ 10 cm DBH per hectare and a closed canopy about 25 m tall with abundant vascular epiphytes and bryophytes. In the classification system of terrestrial ecosystems of Ecuador (Ministerio del Ambiente, 2012) the vegetation type at the site is "bosque siempreverde montano del Norte de la Cordillera Oriental de los Andes". The dominant tree species recorded in the 0.25 hectare include *Wettinia fascicularis* (Arecaceae), *Brunellia pallida* (Brunelliaceae), *Weinmannia pinnata* (Cunoniaceae), *Dicksonia*

sellowiana (Dicksoniaceae), *Abarema killipii* (Fabaceae), *Croton pachypodus* (Euphorbiaceae), *Lozania mutisiana* (Lacistemataceae), *Eschweilara sessilis* (Lecythidaceae), *Hieronyma duquei* and *H. macrocarpa* (Phyllanthaceae). The likely pollinator is an undetermined species of "flea beetle" in the tribe Alticini (Coleoptera: Chrysomelidae; Fig. 2F). There were no seedlings or saplings of this species recorded within the forest inventory plot. Flowering of *M. vargasiana* is recorded from late August to late February but with just a single flower on each occasion. Fruiting possibly takes place in May (pers. comm. by EcoMinga forest ranger Fausto Recalde).

TABLE 1. *Magnolia* species in Ecuador

Species	Distribution in Ecuadorian provinces; other areas
Subsect. *Dugandiodendron*	
• *M. bankardiourum* Dillon & Sánchez-Vega (2009: 7)	Zamora Chinchipe; Perú:
• *M. jaenensis* Marcelo-Peña in Marcelo & Arroyo (2013: 107)	Zamora Chinchipe; Perú: Jaén
• *M. lozanoi* A.Vázquez & Castro-Arce in Vázquez-García *et al.* (2012b: 114)	Morona Santiago
• *M. shuariorum* F.Arroyo & A.Vázquez in Arroyo *et al.* (2013: 505)	Morona Santiago
• *M. stritaifolia* Little (1969: 198)	Esmeraldas; Colombia
• *M. yantzazana* F.Arroyo in Arroyo & Pérez (2013: 5)	Zamora Chinchipe
• *M.* sp. 1	Chocó region: Pichincha
Subsect. *Talauma*	
• *M. canandeana* F. Arroyo, in Arroyo *et al.* (2013: 498)	Esmeraldas
• *M. crassifolia* F. Arroyo & A.J.Pérez in Arroyo *et al.* (2013: 501)	Zamora Chinchipe
• *M. dixonii* (Little 1969: 457) Govaerts in Frodin & Govaerts (1996: 70)	Esmeraldas
• *M. equatorialis* A.Vázquez, in Vázquez-García *et al.* (2012b: 100)	Orellana, Pastaza; Perú:
• *M. kichuana* A.Vázquez, F.Arroyo & A.J.Pérez in Arroyo *et al.* (2013: 501)	Napo, Pastaza, Morona Santiago, Zamora Chinchipe
• *M. llanganatensis* A.Vázquez & D.A.Neill in Vázquez-García *et al.* (in press)	Tungurahua
• *M. neillii* (Lozano 1994: 71) Govaerts in Frodin & Govaerts (1996: 71)	Sucumbíos
• *M. palandana* F.Arroyo in Arroyo & Pérez (2013: 1)	Zamora Chinchipe
• *M. pastazaensis* Arroyo & Pérez (2013: 4)	Pastaza, Napo
• *M. rimachii* (Lozano 1994: 105) Govaerts in Frodin & Govaerts (1996: 71)	Orellana, Morona Santiago; Perú:
• *M. vargasiana* A.Vázquez & D.A.Neill (here proposed as new)	Tungurahua
• *M. zamorana* F.Arroyo in Arroyo *et al.* (2013: 507)	Zamora Chinchipe
• *M.* sp. 2	Chocó region: Cotopaxi, Pichincha, Carchi
• *M.* sp. 3	Amazonían region: Napo: Jatún Sacha y Pastaza: Bobonaza
• *M.* sp. 4	Cordillera Guacamayos: Napo: Cosanga.
• *M. sp. 5*	Andean region: Zampora Chinchipe
unconfirmed from Ecuador	
M. amazónica (Duke 1925: 11) Govaerts in Frodin & Govaerts (1996: 70) (Neill & Ulloa 2011)	Brazil
M. hernandezii (Lozano 1972: 11) Govaerts in Frodin & Govaerts (1996: 71) (Liesner 1999)	Colombia
M. ovata (Saint-Hilaire 1825: 26) Sprengel (1827: 217) (Renner *et al.,* 1990)	Brazil

Timing of flowering:—Once the last hypsophyll has fallen from the flower bud, it is likely that the flower will open within about five days (Fig. 2E). A slightly swollen top of flower bud (Fig. 2F) is a sign that the female phase, day zero (0D) has started. At this phase, the flower will start opening for the first time in the afternoon from 16:49 to 18:00 h until the sepals (3) rotate ca. 90 degrees while the outer petals (5) open nearly 30 degrees and inner petals (3) open < 15 degrees only (Figs. 3A–D); the flower remains partially open for nearly 3 h in order to receive incoming pollinators, "flea beetles" (Tribe Alticini, Chrysomelidae) (Fig. 3E,K). The petals will close at about 21:00 h in the evening, trapping pollinators inside overnight, whereas the sepals stay open overnight until they complete a rotation of ca. 180 degrees (Figs. 3F–H). The following day, the male phase, first day (1D) the petals re-open earlier in the afternoon, beginning at about 14:00 h, when inner the outer petals rotate simultaneously until reaching ca. 90 degrees at about 15:00 h with most of the stamens detached and held in the concave naviculate petals, exposing the pollen and its likely pollinator fully covered in pollen (Figs 3I–L). The outer petals will continue rotating until reaching about 135 degrees at about 18:30. The flower will remain basically unchanged the rest of the day, overnight, throughout most of the following two days (Figs. 2D, 3D) until some or all petals fade and start falling (Figs. 3M–O). Flowers visited by

"flea beetles" show signs of petal damage and then stamen dehiscence takes place sooner (Fig. 31J,L), unlike flowers not visited by the putative pollinators (Fig. M–O). Fragrance is stronger during first opening/reopening of flowers and absent at other times.

Eponymy, ethnobotany and conservation:—This species is named after Dr. Julio Cesar Vargas Burgos, Rector of the Universidad Estatal Amazónica, in recognition of his support for botanical research and development of the ECUAMZ herbarium. No use is yet recorded for this species. Larvae of an unidentified insect were observed eating stamens and petals and damaging some carpels. Several flower buds fell off before completing full development for no evident reason. This species has a narrow distribution, is locally endemic, has a low population density, fails to secure establishment of seedlings and frequently has damaged flower buds. All these features place *M. vargasiana* at high risk of extinction, unless additional and larger populations of this species are found. Based on the information currently available, we recommend the new species be classified as Vulnerable (VU) within the IUCN Red List system (IUCN, 2001).

Other specimens examined:—ECUADOR. Tungurahua: near the Pastaza boundary, Cordillera Llanganates, ca. 7 km (straight line) northeast of Topo, east of Río Zuñac, plot Zuñac 2, quadrat 4, 01°22'06" S, 78°08'59" W, 2000 m, 9 May 2014 (sterile), *Clark*, *Neill* & *Clavijo 14240a* (tree 20), *14240b* (tree 48) (ECUAMZ!, IBUG!); *loc. cit.*, plot and quadrat, September 2014 (fl, fl bud) *Merino-Santi s.n. a* (tree 48) and *b* (tree 20) with Malucín, Jost & the Recalde family (ECUAMZ!, IBUG!); *loc. cit.*, 28 Feb 2014 (fl, & fl bud), *Vázquez-García 10121* with Merino-Santi, Dahua-Machoa, Jost & the Recalde family (ECUAMZ!, IBUG!).

TABLE 2. Differences between *Magnolia vargasiana* and *M. kichuana*

Characters	***M. vargasiana***	***M. kichuana***
Tree		
size (m)	11–26 (–35)	8–15(–25?)
dbh (cm)	20–50 (–110)	15–30
Leaf		
width (cm)	7.5–11.0	13.3–22.0
base	usually cordate	obtuse
Sepals		
size (cm)	3.6–3.7 × 1.8–2.0,	4.0–5.3 × 1.3–1.8
shape	oblong	broadly oblong
Open flowers (cm)	7.0–7.5	9.0–10.5
Outer petals		
Length (cm)	3.5–3.8	(4.3–)5.8–8.2
shape	obovate-spathulate	narrowly oblanceolate
	strongly concave	barely concave
Inner petals		
length (cm)	(2.0–)3.2–3.5	(3.5–)5.0–0.7
shape	obovate-spathulate	linear-lanceolate
Flower bud		
length (cm)	1.5–2.8	3.5–4.0
shape	ellipsoid	oblongoid
No. of stamens	50–54	38–42(–50)
Gynoecium length (cm)	1.5–1.7 × 0.7–0.8	1.2–1.4 × 0.5

Key to *Ecuadorian* species of *Magnolia* sect. *Talauma* subsect. *Talauma**

1. Carpels 5–20, stamens 20–90 2
- Carpels 35–135, stamens 105–175 7
2. Leaves suborbicular, cordate, broadly ovate, rarely broadly elliptic 3
- Leaves elliptic to lanceolate or broadly elliptic 4
3. Mature leaf blades 6–11 cm long, outer petals obovate–spathulate and strongly concave ..... *Magnolia vargasiana*
- Mature leaf blades 15–22 cm long, outer petals narrowly oblanceolate and slightly concave ..... *Magnolia kichuana*
4. Leaf blades at least abaxially pubescent 5
- Leaf blades mostly glabrous or glabrescent in both sides 6

5. Petals 3–3.3 cm long; fruit 4 cm long, lateral nerves 13–15 per side ..... *Magnolia zamorana*
- Petals 1.5–2 cm long; fruit 3 cm long, lateral nerves 8–12 per side ..... *Magnolia palandana*
6. Carpels 4–6, stamens 20–25 (Cordillera Llanganates, Ecuador) ..... *Magnolia llanganatensis*
- Carpels 14–18, stamens 81–87 ..... *Magnolia rimachii*
7. Carpels unbeaked 8
- Carpels strongly beaked at the tip 9
8. Carpels 124–132 ..... *Magnolia dixonii*
- Carpels 96–104 ..... *Magnolia canandeana*
9. Petioles and internodes pubescent, carpels 35–40 ..... *Magnolia neillii*
- Petioles and internodes glabrous or glabrescent, carpels 78–122 10
10. Fruit obovoid, mature leaves 28.0–55.0 × 12.0–26.5 cm; lateral leaf veins per side 10–22 ..... *Magnolia equatorialis*
- Fruit ovoid, mature leaves 16.0–26.0 × 6.0–17.0 cm, lateral leaf veins per side 6–9 ..... *Magnolia pastazaensis*

**Magnolia crassifolia* has insufficient data in its protologue and therefore was excluded from the key; three other species erroneously reported from Ecuadorian Amazonia were also excluded (Table 1): *M. amazonica* listed by Neill & Ulloa (2011), based on *Macia et al. 1180* (QCA!, MO), from Yasuní, Orellana, which corresponds to *M. equatorialis; M. hernandezii* listed as doubtfully determined for the *Catalogue of vascular plants of Ecuador* (Liesner 1999), based on *Palacios 11401* (QCNE!), from Palora, Morona Santiago, which corresponds to *M. kichuana*; and *M. ovata* (Renner *et al.,* 1990), based on *Øllgaard et al. 57126* (AUU!), from Añangú, Yasuni, Orellana, a sterile specimen and most likely corresponds to *M. equatorialis*.

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