ARTÍCULO CIENTÍFICO

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MCB

Revista Ecuatoriana de Medicina
y Ciencias Biológicas
Volumen 43. No. 2, Noviembre 2022

An amended description for *Magnolia arroyoana* (Magnoliaceae) and a proposal for the new *Stenopetalae* group

Redescripción de *Magnolia arroyoana* (Magnoliaceae) y la propuesta del nuevo grupo *Stenopetalae*

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Recibido: 21-03-2022
Aceptado: 06-11-2022

DOI: 10.26807/remcb.v%vi%i.922

e-ISSN 2477-9148

Como citar este artículo:
Rea E, Pérez ÁJ, Burgess K, Cevallos D, Zapata JN, Jácome X, Navarrete H, Vázquez-García JA. An amended description for *Magnolia arroyoana* (Magnoliaceae) and a proposal for the new Stenopetalae group. .Revista Ecuatoriana de Medicina y Ciencias Biológicas 43(2): 11-21. doi: 10.26807/remcb.v%vi%i.922

Abstract.- During recent botanical explorations in the Zamora-Chinchipe Province (Ecuador), a new population of *Magnolia arroyoana* was registered, and following IUCN criteria, the species is ranked as critically endangered (CR). To update the taxonomy of this species, we provide the first description of its mature flowers and immature fruits, present the first images of all its structures, and provide a current distribution map. Additionally, relationships with other morphologically similar species are discussed, and as a result, we propose the hypothetical morphological group *Stenopetalae*, within the section *Talauma*.

Keywords: Ecuador, Neotropics, *Magnolia* sect. *Talauma*, Taxonomy, Zamora-Chinchipe.

Resumen.- Durante las recientes exploraciones botánicas en la provincia de Zamora Chinchipe (Ecuador), una nueva población de *Magnolia arroyoana* fue registrada, y con base a los criterios de la IUCN, la especie es catalogada en Peligro Crítico (CR). Para actualizar la taxonomía de esta especie, presentamos la primera descripción de sus flores maduras y frutos inmaduros, las primeras imágenes de todas sus estructuras, y un mapa de distribución actualizado. Adicionalmente, se discuten las relaciones con otras especies morfológicamente similares, y como resultado, se concluye proponiendo la hipótesis del grupo morfológico *Stenopetalae* dentro de la sección *Talauma*.

Palabras clave: Ecuador, Neotrópico, *Magnolia* sect. *Talauma*, Taxonomía, Zamora Chinchipe.

Introduction

Over the last decade, studies of Ecuadorian *Magnolia* have revealed extraordinary species diversity within the country; currently, 23 taxa have been recorded in over a dozen publications (Arroyo and Pérez 2013; Arroyo et al. 2013, 2019; Molinari-Novoa 2016; Morelos-Juárez et al. 2019; Pérez 2015, Pérez et al. 2016, 2020; Vázquez-García et al. 2012, 2013a, 2014, 2015, 2016a, 2017). Nevertheless, the Ecuadorian magnolias face numerous conservation challenges due to habitat loss, selective logging, and low regeneration rates. Consequently, 82% of the species in Ecuador are considered to be at risk of extinction (Vázquez-García et al. 2013a, Rivers et al. 2016).

During recent botanical explorations in the Zamora-Chinchipe province of Ecuador, we registered a new *Magnolia* locality, where *M. yantzazana* F. Arroyo, *M. zamorana* F. Arroyo and *M. arroyoana* Molinari were found to coexist. Based on this discovery, in the current study, we provide the first description of the mature flowers and immature fruits of *M. arroyoana* (only known in bud) and an updated taxonomic description of the species. Below, we also include the first images of all its structures and a map of its current distribution; the conservation status of *M. arroyoana* and its relationships with other species are also discussed (Figures 1–5). We conclude with a proposal for the designation of the hypothetical morphological *Stenopetalae* group within the section *Talauma* and the urgent need for molecular analysis of the Neotropical magnolias to clarify their phylogenetic relationships and evolutionary history.

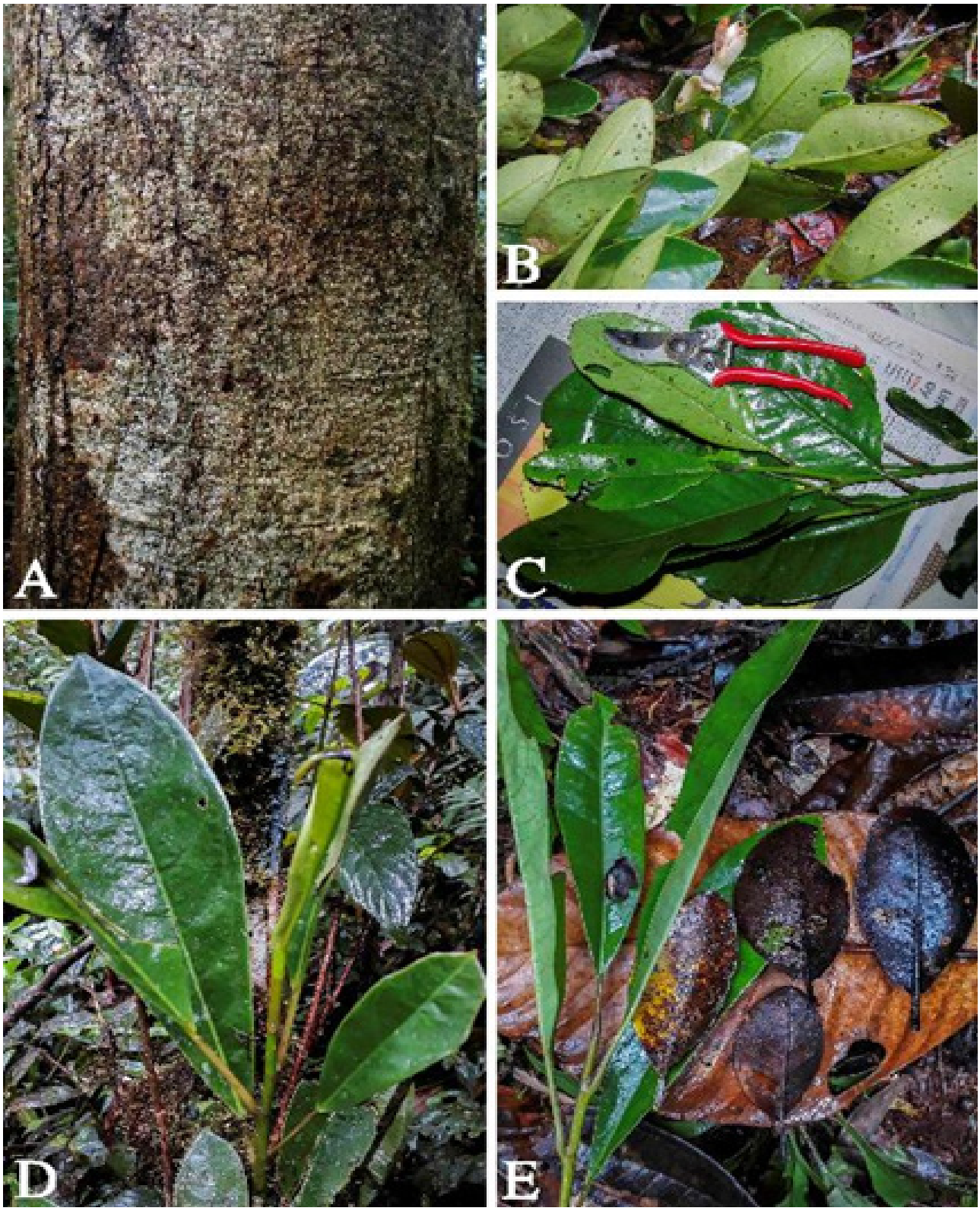

Figure 1. *Magnolia arroyoana*. **A**. Outer bark. **B**. Branch showing the abaxial side of the leaves from an adult individual. **C.** Branch showing the adaxial side of the leaves from a sub-adult individual. **D**. Leaf blades shape from a juvenile individual. **E.** Comparison between leaves from juvenile (green leaves) and adult individuals (brown leaves). A, B from *Pérez et al. 11667* (QCA), C from *Arroyo et al. 292* (QCA), D, E from *Pérez et al. 11662* (QCA). Photographs by: Álvaro J. Pérez.

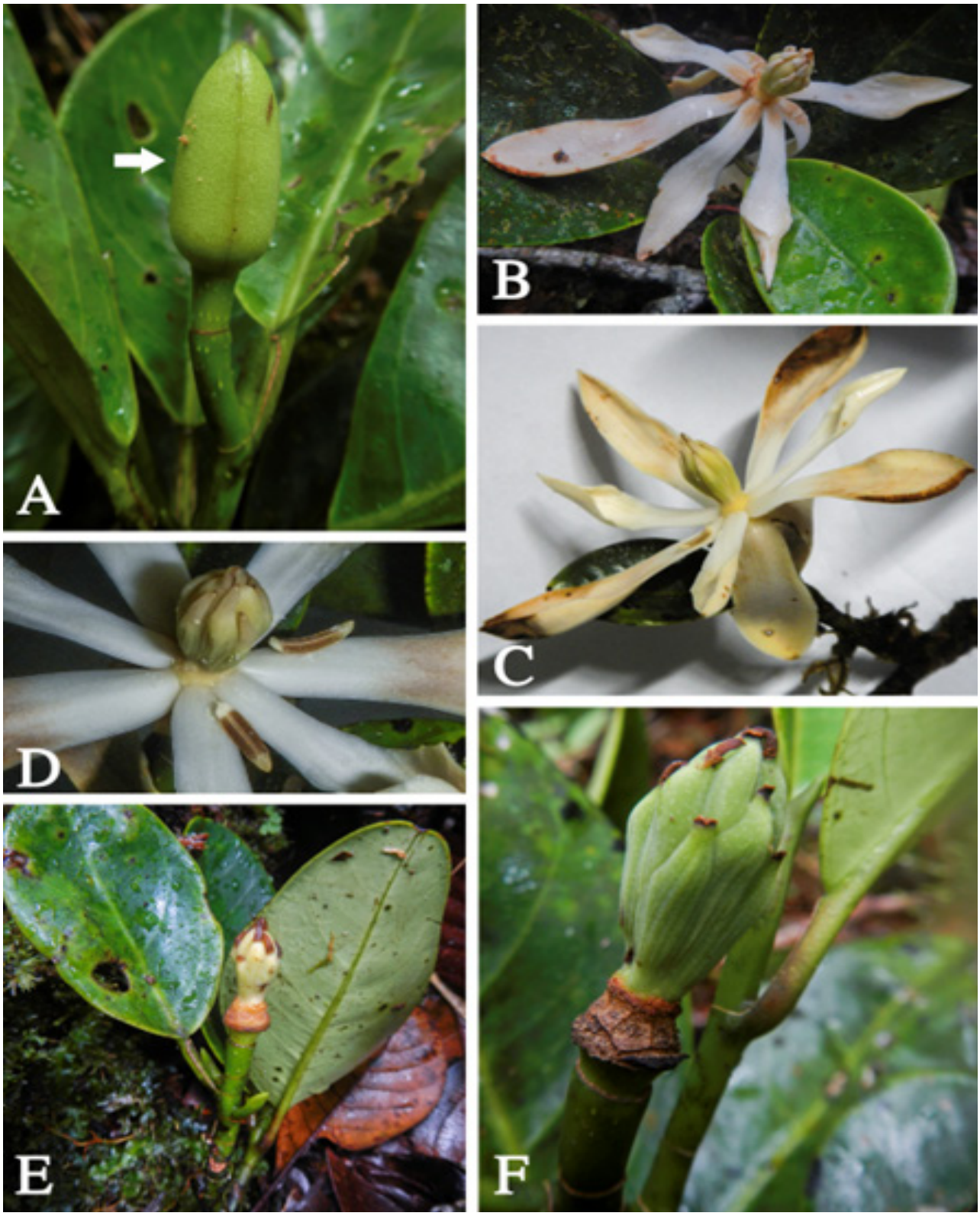

Figure 2. *Magnolia arroyoana*. **A.** Flower bud showing hypsophylls. **B, C.** Flower finishing the male phase. **D.** Flower showing gynoecium and stamen. **E, F.** Immature fruits. A–F from *Pérez et al. 11667* (QCA). Photographs by: Álvaro J. Pérez.

Materials and Methods

During floristic inventories carried out in February 2020, in the Fruta del Norte mining concession, Zamora-Chinchipe Province, a new population of *M. arroyoana* was found 12 km away from the type locality. During this time, we obtained the ephemeral flowers, a couple of young fruits (Figures 1, 2) and phenological data.

Fresh material and pictures form the basis of the expanded morphological re-description of *M. arroyoana*. Detailed observations and measurements of reproductive structures were made with the aid of a dissecting microscope. Major characters were contrasted among all six members of the proposed hypothetical morphological *Stenopetalae* group (Table 1). Additionally, we consulted pertinent literature, revised specimens at ECUAMZ, F, MO, QCA, QCNE and WIS, and high-resolution images of the type material of Neotropical taxa (Tropicos database, https://www.tropicos.org/ and the JSTOR Global Plants website http: //plants.jstor.org).

We used the online GeoCat utility to upload the coordinates for two known populations of *M. arroyoana* to obtain its area of occupancy (AOO) (Bachman et al. 2011) and to assess its conservation status (IUCN 2022).

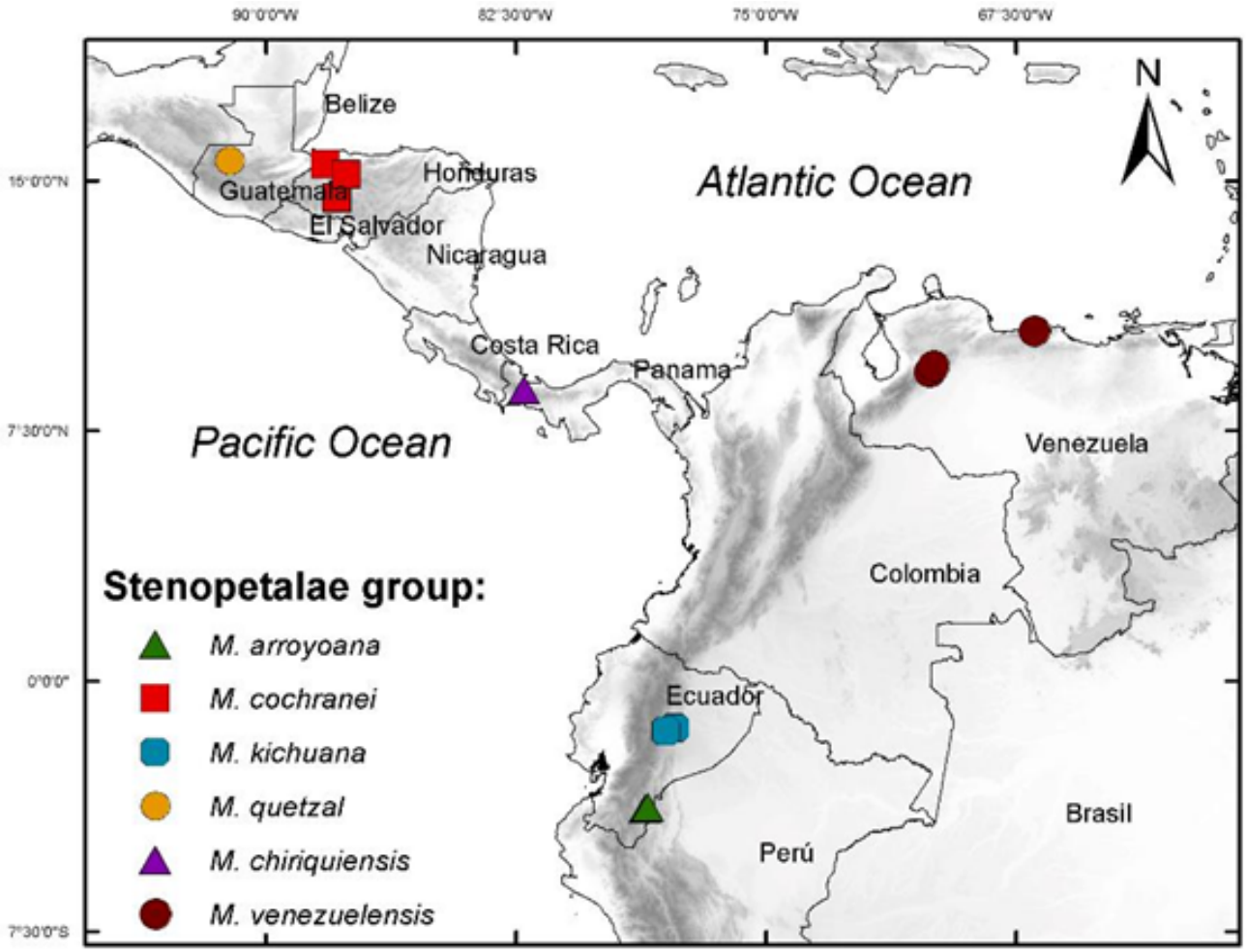

Figure 3. Distribution map for the species of the hypothetical morphological *Stenopetalae* group.

Figure 4. Habitat of *Magnolia arroyoana* in the Machinaza river basin, Zamora-Chinchipe Province, southern Ecuador. Photograph by: Xavier Jácome.

Results

Taxonomic treatment

Magnolia arroyoana Molinari, Phytotaxa 257 (2): 200–200. 2016.

Magnolia crassifolia F. Arroyo & Á.J. Pérez, Recursos Forest. Occid. México 2: 501, f. 10.2.3. 2013, nom. illeg., non *Magnolia crassifolia* Göpp. (1852:277), a fossil.

TYPE: Ecuador, Zamora-Chinchipe, Los Encuentros, km 10 en carretera a Jardín del Cóndor, en cerros al lado derecho de la carretera, 1613 m, 3°48´20.6"S, 78°36´45"W, 8 Aug. 2013 (fl bud). *F. Arroyo & Á.J. Pérez 292* (holotype QCA!).

Figures 1, 2

Trees 10.0–25.0 m tall, 15.0–60.0 cm dbh; outer bark beige, inner bark yellowish; branchlets terete, 0.4–0.6 cm in diam, glabrous. Stipules glabrous, 1.0–1.5 cm long in adult individuals, up to 5.0 cm long in juveniles. Leaves in adults and sub-adults elliptic, oblong-elliptic or oblong, 5.0–37.0 × 3.0–16.0 cm, in juveniles oblanceolate, 15.0–27.0 × 4.0–8.0 cm, in all stages glossy and smooth above, dull beneath, glabrous on both surfaces, coriaceous, the apex obtuse to rounded, the margins entire, somewhat revolute, the base acute to slightly attenuate, sometimes obtuse; lateral veins 6–12 on each side of the midrib, the midrib impressed to slightly raised above, prominent beneath, the lateral veins prominulous to impressed above, prominulous beneath, the reticulate venation prominulous to obscure above, vaguely notorious beneath; petioles semiterete, 1.0–2.2 × 0.2–0.4 cm in adult individuals, 2.5–6.0 × 0.2–0.3 cm in juveniles, glabrous, with plain adaxial scar covering its entire length. Hypsophylls 2, glabrous. Flowers solitary, terminal; flower bud ellipsoid, 2.7 × 1.1 cm, glabrous; open flowers 7.0–8.0 cm in diameter; sepals 3, 3.5–3.7 × 1.0–1.2 cm, creamy white, oblong, slightly truncate at base, obtuse at apex, concave, glabrous, clearly contrasting from petals in shape; petals 7, spatulate with a long attenuate base, slightly naviculate, fleshy, white or creamy white, erect, fragrant, the outer ones 4.0–4.8 × 0.8–1.3 cm (4:1), the inner ones 3.3–4.0 0.7–1.0 cm (5:1); stamens 20–23, 0.7–1.1 × 0.1–0.2 cm, arranged in one series, acute at the apex; gynoecium ellipsoid, 1.5–1.8 cm long, with 10–12 carpels. Fruit ellipsoid, immature, 2.8 × 2.1 cm, greenish, carpels gibbose, the basal ones longitudinally ribbed; seeds not seen.

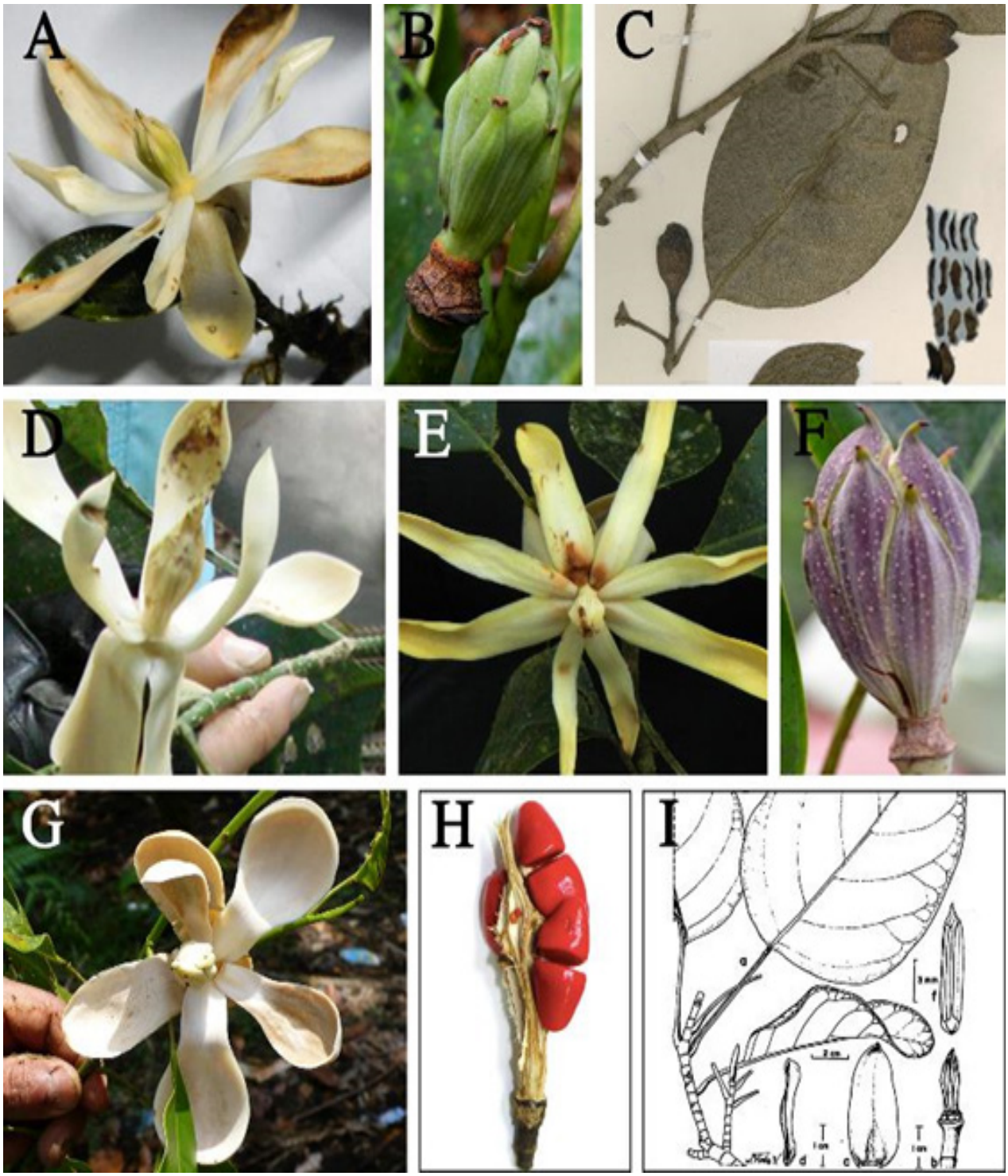

Figure 5. Species of the hypothetical morphological *Stenopetalae* group. **A, B.** *Magnolia arroyoana.* **C.** *Magnolia chiriquiensis.* **D.** *Magnolia cochranei*. **E, F.** *Magnolia kichuana.* **G, H.** *Magnolia quetzal.* **I.** *Magnolia venezuelensis.* Photographs by: A, B by Álvaro J. Pérez, C–F by Antonio Vázquez, G by Erick Tribouillier, H by Mario Véliz Pérez, I reprinted with permission from: Lozano-Contreras G. 1990. Magnoliaceae nativas de Venezuela. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 17(67): 779-782.

Table 1. Morphological differences among species of the hypothetical morphological *Stenopetalae* group.

Characters	*M. arroyoana*	*M. venezuelensis*	*M. kichuana*	*M. quetzal*	*M. chiriquiensis*	*M. cochranei*
Leaves						
Size (cm)	5.0–37.0 × 3.0–16.0	13.1–21 × 7.9–14	6.2–22.0 × 10.6–12.5	(7.5–)15.0–20.0 × 6.9–8.1	13.0–26.5 × 7.0–15.5	8.0–24.0 × 6.0–15.0
Shape	Elliptic, oblong-elliptic or oblong in adults and oblanceolate in juveniles	Broadly ovate	Broadly elliptic to ovate or suborbicular	elliptic to lanceolate, or obovate, apex acute or obtuse	Broadly ovate-elliptic, apex acuminate, base obtuse	Ovate to broadly elliptic
Petiole size (cm)	1.0–6.0 × 0.2–0.4	3.8–6.5 × 0.2–0.3	2.7–13.1 × 0.2–0.3	2.5–5.0 × 0.1–0.7	2.0–4.8 × 0.2–0.5	2.4–8.3 × 0.2–0.35
Secondary veins	6–12	10–11	6–9	8–9	8–11	7–10
Hypsophylls	2	3	2	¿?	3	4–5
Flower						
Size in diam (cm)	7.0–8.0	8.0–9.0	10.0–12.0	7.0–8.0	8.0–9.0	10.0–12.5
Petal						
Number	7	8	8	6	8	6
Size						
outer ones (cm)	4.0–4.8 × 0.8–1.3 (4:1)	4.0–4.5 × 1.0(4:1)	4.3–5.8 × 1.6–1.8	3.6–3.8 × 1.9–2.0	4.0–4.5 × 0.9–1.1	6.8–7.0 × 2.5–3.2
inner ones (cm)	3.3–4.0 × 0.7–1.0 (5:1)	2.0–2.5 × 0.5(4:1)	2.0–3.7 × 0.8–1.4	3.4–3.6 × 1.7-1.8	2.8–3.0 × 0.6–0.7	4.5–5.0 × 1.8–2.0
Shape	Spathulate	Spathulate	Oblanceolate	obovate	Spathulate	Spathulate
Stamens	20–23	31–33	38–42(–50)	40–44	52–54	72–82
Mature Fruit						
Size (cm)	Unknown	Unknown	5.8–6.2 × 3.4	7.0–7.5 × 3.2–3.5	Unknown	Unknown
Shape			Obovoid	Ellipsoid		Ovoid
Carpels number	Ellipsoid	Unknown	10–12	8–10	Unknown	7–9
	10–12	11			10	
Distribution	SE Ecuador	Colombia and Venezuela	E Central Ecuador	Guatemala	Panamá	Honduras
Altitude m asl	1495–1613	1300–1500	800–1800	1500–1600	1050–1100	1300–2000

Eponymy, discovery, and ethnobotany.- This species was published as *Magnolia crassifolia*, but the name is illegitimate, being a later homonym of *M. crassifolia* Göpp. (Göppert 1852), a fossil taxon. Based on Art. 6.11 of ICN, Molinari-Novoa (2016) proposed *M. arroyoana* as a new and valid name for this taxon (Figures 1, 2), which was named in honor of Frank Arroyo, a Peruvian botanist from Universidad Agraria La Molina. The first collection of this species came from two sprouting stumps collected by F. Arroyo while exploring the forest remnants around the Los Encuentros - Jardín del Cóndor road; a few days later, he returned to the area with Á.J. Pérez to expand the search. Here, they found a couple more individuals, one of them having young flower buds that were used to describe the species. The inhabitants of this area recognize that the timber of *M. arroyoana* is suitable for use in carpentry and cabinetmaking, but the species does not have a common name.

Distribution and ecology.- Endemic to Zamora-Chinchipe Province in southeastern Ecuador, the type population is located in a private remnant forest along the Los Encuentros - Jardín del Cóndor road, at 1613 m. The recently discovered population is located in forest remnants along the Los Encuentros - El Pindal - Campamento Las Peñas road, km 14+800 m, at 1495 m (Figure 4). The type locality lies within a much larger zone that covers the southern portion of the eastern Cordillera de Los Andes (Ministerio del Ambiente del Ecuador 2013) and is dominated by evergreen piedmont forest; the new population lies in the evergreen low montane forest of the Cordilleras del Cóndor and Kutukú (Figure 5). An adult individual (sample *Pérez et al. 11667*) has been monitored since 2019 in the Colibrí plot (2500 m^2) as part of a monitoring program conducted by the Lundin Gold company. The plant is 32 cm dbh and has a growth rate of ~1 mm/year. Flower buds are typically present in August, flowering in January–February and mature fruits possibly form from May to June.

Conservation status.- *M. arroyoana* has an AOO of 0.20 km^2 and is ranked as Critically Endangered (CR), meeting criteria B2b(iii), D of IUCN (IUCN 2022), and is still in agreement with the latest Red List of Magnoliaceae (Rivers et al. 2016). Despite adding a new population, we recommend maintaining this category due to low population density (less than 15 individuals are known; two adults and seven juveniles were seen in the new locality) and the high threat of habitat loss (Arroyo et al. 2013; Vázquez-García et al. 2016b).

Additional specimens examined.- ECUADOR. Zamora-Chinchipe: Los Encuentros, 10 km en carretera a Jardín del Cóndor, en cerros al lado derecho de la carretera, 1571 m, 03°48'23"S, 78°36'38"W, 01 Aug. 2013 (sterile), *Arroyo & León 282* (QCA!); same locality as previous, 1564 m, 03°48'23"S, 78°36'37"W, 01 Aug. 2013 (sterile), *Arroyo & León 283* (QCA!); camino Los Encuentros - El Pindal - Campamento Las Peñas, km 14+800 m, Parcela Colibrí, 1495 m, 03°45'20"S, 78°33'02"W, 01 Feb. 2020 (fl, inmature fr), *Pérez et al. 11662, 11667* (QCA!).

Discussion

M. arroyoana belongs to the *Magnolia* section *Talauma*. The species is morphologically similar to *M. kichuana* (Arroyo et al. 2013) because its flowers have oblong sepals and spathulate petals, although the flowers are smaller for *M. arroyoana* (7.0–8.0 cm diam vs. 10.0–12.0 cm diam for *M. arroyoana* and *M. kichuana*, respectively). Another similarity is the carpel number, which ranges from 10–12 for both species.

The two species differ in petiole length (*M. arroyoana*, 1.0–6.0 × 0.2–0.4 cm; *M. kichuana*, 2.7–13.1 × 0.2–0.3 cm) and fruit shape (ellipsoid vs. obovoid in *M. arroyoana* and *M. kichuana*, respectively). For *M. arroyoana*, the leaf blades are elliptic, oblong-elliptic or oblong in the adults (oblanceolate in juveniles), whereas they are broadly elliptic to ovate or suborbicular in *M. kichuana*. In addition, the number of stamens ranges from 20–23 for *M. arroyoana* vs. 38–42(–50) for *M. kichuana*.

A Colombian endemic species, *M. virolinensis* (Lozano) Govaerts, is also morphologically similar to *M. arroyoana* for its vegetative characters. Still, these two species differ in 1) how their adaxial scars cover the petiole (fully covered vs. partially covering in *M. virolinensis*), 2) branchlet pubescence (entirely glabrous vs. puberulent in *M. virolinensis*) and hypsophyll pubescence (glabrous vs. pubescent in *M. virolinensis*) (Lozano-Contreras 1994).

M. arroyoana is morphologically related to a set of species proposed here as the hypothetical morphological *Stenopetalae* group within the section *Talauma*. Based on their flower and fruit morphology, taxa in this newly defined group share spathulate or narrowly obtrullate to oblanceolate petals (4:1–5:1), having a long attenuate base and small ellipsoid to obovoid fruit of few (<12) gibbose carpels. This group includes *M. cochranei* A.Vázquez, *M. quetzal* A.Vázquez, Véliz & Tribouill., *M. chiriquiensis* A.Vázquez (Vázquez-García et al. 2013b), *M. venezuelensis* (Lozano) Govaerts (Lozano-Contreras 1990, 1994), and *M. kichuana* (Figures 3, 5; Table 1). Future genetic analyses are needed to confirm the classification of these species in the proposed hypothetical morphological *Stenopetalae* group, which may elevate the taxon to a higher systematic category (i.e., Series).

Key to species of the *Stenopetalae* group

1. Stamens > 50 2
- Stamens ≤ 50 3
2. Leaf apex acuminate, secondary veins 8–11; hypsophylls 3; flowers 8.0–9.0 cm in diam; petals 8, the outer petal length 4.0–4.5 cm; stamens 52–54; Panama ..... *M. chiriquiensis*
- Leaf apex acute to obtuse, secondary veins 7–10; hypsophylls 4–5; flowers 10.0–12.5 cm in diam; petals 6, the outer petal length 6.8–7.0 cm; stamens 72–82; Honduras ..... *M. cochranei*
3. Stamens > 35 4
- Stamens ≤ 35 5
4. Leaves broadly elliptic to suborbicular; flower 10.0–12.0 cm in diam; fruit 5.8–6.2 cm long; eastern-central Ecuador ..... *M. kichuana*
- Leaves elliptic to lanceolate, occasionally obovate; flower 7.0–8.0 cm in diam; fruit 7.0–7.5 cm long; Guatemala ..... *M. quetzal*
5. Leaves broadly ovate; hypsophylls 3; petals 8; stamens 31–33; Venezuela and Colombia ..... *M. venezuelensis*
- Leaves elliptic, oblong-elliptic, oblong or oblanceolate; hypsophylls 2; petals 7; stamens 20–23; southeastern Ecuador ..... *M. arroyoana*

Acknowledgements

We are grateful to Lundin Gold and Cardno Entrix for facilitating the floristic inventories in the Fruta del Norte mining concession in Zamora-Chinchipe Province through the research agreement with the Pontificia Universidad Católica del Ecuador (N° 2018-001). We thank the curators of herbaria listed under the methods section for the facilities provided to study their Magnolia collections. Special thanks to Dra. Elizabeth Castañeda, editor in chief of Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales for authorizing the reprint of figure 3 of Lozano-Contreras paper in 1990 and to María José Racines (Entrix coordinator) for all the support during the fieldwork. Thanks to the anonymous reviewers that improved our manuscript.

Declaration of interest and Authors' Contributions

All authors declare that there is no conflict of interest. ÁJP, NZ, and ER collected and photographed the plants. ÁJP, NZ, DC and JAVG identified the specimens and revised herbarium collections. All authors contributed equally to the writing of the text.

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