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Article *in* Brittonia · January 2021

DOI: 10.1007/s12228-020-09650-9

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Rediscovering the genus *Lubaria* (Rutaceae: Galipeinae), a new species and first record for Colombia

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Abstract. A new species from the northern foothills of the central Andes of Colombia belonging to the previously monotypic genus *Lubaria* (Sapindales: Rutaceae) is here described and illustrated; comments about its distribution, habitat and conservation status are made. Named ***L. heterophylla***, it differs from *L. aroensis* by its trifoliolate leaves (one of the two at a node is smaller and frequently bifoliolate or simple), smaller flowers, and blunt anther connective. Given the vast unexplored area between the location of *L. heterophylla* and those of *L. aroensis* in Venezuela and Costa Rica, further explorations in the continental southern Caribbean basin could help to find additional populations of both species. Leaf form and size variation found in this new species might be a mechanism of phenotypic plasticity probably related to limiting transpiration during dry seasons.

Keywords: Botany, endangered species, flora of Colombia, neotropics, plant taxonomy.

Resumen. Se describe e ilustra una nueva especie del hasta ahora monotípico género *Lubaria*, con distribución en colinas bajas al norte de los Andes centrales de Colombia; se hacen comentarios sobre su distribución, hábitat y estado de conservación. Llamada ***L. heterophylla***, difiere de *L. aroensis* por sus hojas trifolioladas (una de las dos en cada nudo siendo ligeramente más pequeña y frecuentemente bifoliolada o simple), flores más pequeñas y ápice del conectivo de las anteras no prominente. Dada la vasta área entre la localización de *L. heterophylla* y los registros de *L. aroensis* en Venezuela y Costa Rica, exploraciones posteriores en la parte continental del sur de la cuenca del Caribe podrían ayudar a encontrar poblaciones adicionales de ambas especies. La variación morfológica de las hojas en esta nueva especie parece sugerir un mecanismo de plasticidad fenotípica posiblemente asociado a limitar la transpiración durante temporadas secas.

Lubaria Pittier has been one of many monotypic genera of the subtribe Galipeinae of the highly diverse and nearly cosmopolitan angiosperm family Rutaceae (Kubitzki et al., 2011). This family comprises about 160 genera and 2100 species (Kubitzki et al., 2011; Cole et al., 2018) of which several are of global economic importance as edible fruits (mainly *Citrus*), ornamentals, sources of medicinal and aromatic compounds and timber (e.g. *Amyris* P. Browne, *Casimiroa* La Llave, *Chloroxylon* DC., *Murraya* J. Koenig, *Phellodendron* Rupr., *Ruta* L. and *Zanthoxylum* L.) (Mabberley, 2017). Rutaceae also has a remarkable generic diversity in the Neotropics which has been confusing for many taxonomists because of the complex and continuous variability among genera and the

Received 2 February 2020; revised 24 October 2020; accepted 11 December 2020.

Published online: 19 January 2021

incomplete morphological knowledge of many of them. Within the family, Kubitzki et al. (2011) recognized three subfamilies based on a combination of morphological, chemical and DNA evidence: Aurantioideae, Cneoroideae and Rutoideae. More recent molecular-only based studies have suggested either four subfamilies: Amyridoideae, Aurantioideae, Cneoroideae and Rutoideae (Morton & Telmer, 2014) or two: Cneoroideae and Rutoideae (Groppo et al., 2012; Cole et al., 2018).

Based on the description of the only previously known species, *Lubaria aroensis* Pittier, the genus is delimited by the combination of arboreal habit, simple opposite leaves, terminal several-branched dichasia with monochasial branches, pentamerous flowers with calyx lobes imbricate and the two outermost ones larger than the others, white zygomorphic (bilabiate) corolla with one free adaxial innermost petal (minor lip) and four connate petals (major lip), androecium of two fertile stamens flanking the minor lip and three staminodes alternating with the lobes of the major lip, filaments connate, anthers with apiculate apex and a basal appendage, and fruits with one to five follicles. At first glance, the specimens of *L. aroensis* could be placed in other families with simple opposite leaves and zygomorphic flowers, like Pittier (1929) reported, who initially found them misplaced in the Acanthaceae .

Lubaria is considered part of the subtribe Galipeinae (=Angostura alliance of Kubitzki et al., 2011), of which most genera are characterized by some combination of characters such as zygomorphic flowers, more or less tubular corollas, sterilization of stamens and presence of staminodes, variously modified anthers, seeds lacking endosperm and plicate cotyledons (Groppo et al., 2008; Kubitzki et al., 2011). Galipeinae is part of the subfamily Rutoideae (Kubitzki et al., 2011; Groppo et al., 2012; Cole et al., 2018) and DNA based phylogenetic studies have also suggested that it is a monophyletic group (Bruniera et al., 2015; Groppo et al., 2017; Cole et al., 2018); however, *Lubaria* as well as several other genera have not been yet included in a published molecular analysis of Rutaceae. Here, a new species of *Lubaria* from forest remnants in the middle part of the Magdalena River basin in north-central Colombia is described and illustrated, along with comments about its distribution, habitat and conservation status. In the species description, details of the leaf venation were described following the terminology of Ellis et al. (2009), the conservation status employing the IUCN Red List categories and criteria (IUCN, 2012) was established with R packpage "ConR" (Dauby, 2019; Protected Planet, 2019; R Core Team, 2019), and the distribution map was made on Arcgis 10.5.

Lubaria heterophylla Londoño-E., Ana Trujillo & Pérez Zab., **sp. nov.** Type: Colombia, Antioquia, Mun. Remedios: vereda Río Negrito, quebrada El Recreo, 6°53′55.04″N, 74°29′20.07″W, 350 m, 05 Mar 2018 [fl], *Y. Londoño & J. A. Pérez 214* (holotype: MEDEL; isotypes: COL, HUA). (Figs. 1 & 2.)

Diagnosis: *Lubaria heterophylla* differs from *L. aroensis*, the only other species in the genus, by its palmately trifoliolate (vs. simple) leaves of which one of the pair at a node has a shorter petiole, smaller leaf blades, and frequently only one or two leaflets, its shorter calyx (1.5–1.9 vs. 3–4 mm long), shorter corolla (9–11.5 vs. 13–16 mm long), and an apically blunt (vs. apiculate) anther connective.

Shrub or treelet up to 6 m tall, the branches villous, glabrescent, lenticellate, slightly pendulous. *Leaves* opposite, petiolate, usually palmately trifoliolate, but one of the pair at a node on a shorter petiole and sometimes bifoliolate or less frequently simple; petiole terete, villous, the longer at a node (11–) 30–45 (–67) × 0.6–1 mm, the shorter one (3–) 5–16 (–29) × 0.5–0.9 mm; petiolules villous, the petiolule of terminal leaflet of trifoliolate leaves (and of the longer leaflet of bifoliolate leaves) 1–10 × 0.5–0.8 mm, the petiolule of the lateral leaflets of trifoliolate leaves (and of the shorter leaflet of bifoliolate leaves) 1–6 × 0.6–0.8 mm; terminal leaflet of trifoliolate leaves 6.3–10.4 × 2.3–4 cm, blade of simple leaves 2.8–6.2 × 1.3–2.8 cm, both medially and basally symmetrical; lateral leaflets of trifoliolate leaves (2.4–) 7.8–9.2 (–12) × (0.9–) 2.5–4.2 cm, medially asymmetrical, basally with asymmetrical insertion; leaflets of bifoliolate leaves 4.1–9.2 × 1.3–3.7 cm, medially symmetrical or asymmetrical, basally symmetrical or with asymmetrical insertion; blade of leaflets elliptic, elliptic-ovate or rarely obovate, the base acute, straight or convex, when asymmetrical one side concave, the apex acute, straight or acuminate, sometimes mucronate, villous on only the primary and secondary veins adaxially, sparsely so on surface and densely so on primary and secondary veins abaxially, the margin entire, hispidulous-ciliate,

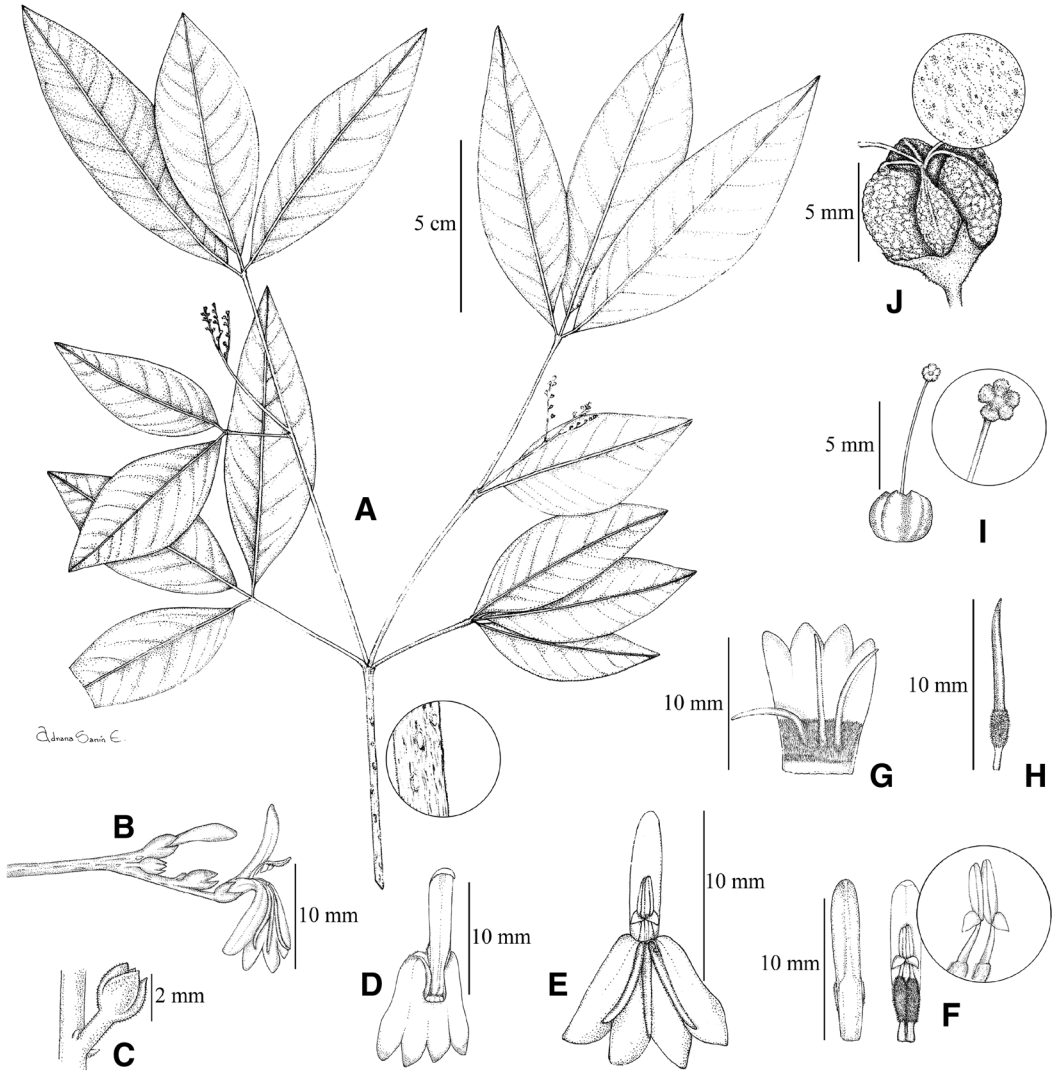

Fig. 1. *Lubaria heterophylla*. **A.** Habit and young inflorescence, zoomed view of branches surface. **B.** Inflorescence. **C.** Calyx in bud. **D.** Union of corolla lips. **E.** Flower (frontal view). **F.** Minor lip (abaxial and adaxial view) and the fertile stamens, zoomed view of the anthers. **G.** Major lip and staminodes. **H.** Staminode. **I.** Disc, style and stigma (zoomed view). **J.** Immature fruit with styles still present, zoomed view of the surface. (A, C from *Londoño & Pérez 237*; B, D–I from *Londoño & Trujillo 240*; J from *Londoño & Trujillo 84*. Drawn by Adriana Sanín E., HUA illustrator.)

glandular-punctations impressed adaxially and slightly raised abaxially; venation pinnate, simple brochidodromous; major secondaries 9–13 on each side of the midvein, (sub)equidistant, departing the midvein at ca. 60°; marginal fimbrial vein present; intersecondary veins >50% of the length of the subjacent secondary, ca. 1 per intercostal area, proximal course parallel to major secondaries, distal course reticulating or ramifying; intercostal tertiary veins irregular reticulate; epimedial tertiary veins reticulate; exterior tertiary veins looped; quaternary and quinternary vein fabric irregularly reticulate; areolation moderate; ultimate marginal venation incomplete. *Inflorescence* terminal, a dichasium (simple or up to twice-forked, with monochasial branches), 2.5–7 (–12.7) cm long including a peduncle 0.5–5 × 0.1 cm, bearing (3–) 13–20 (–

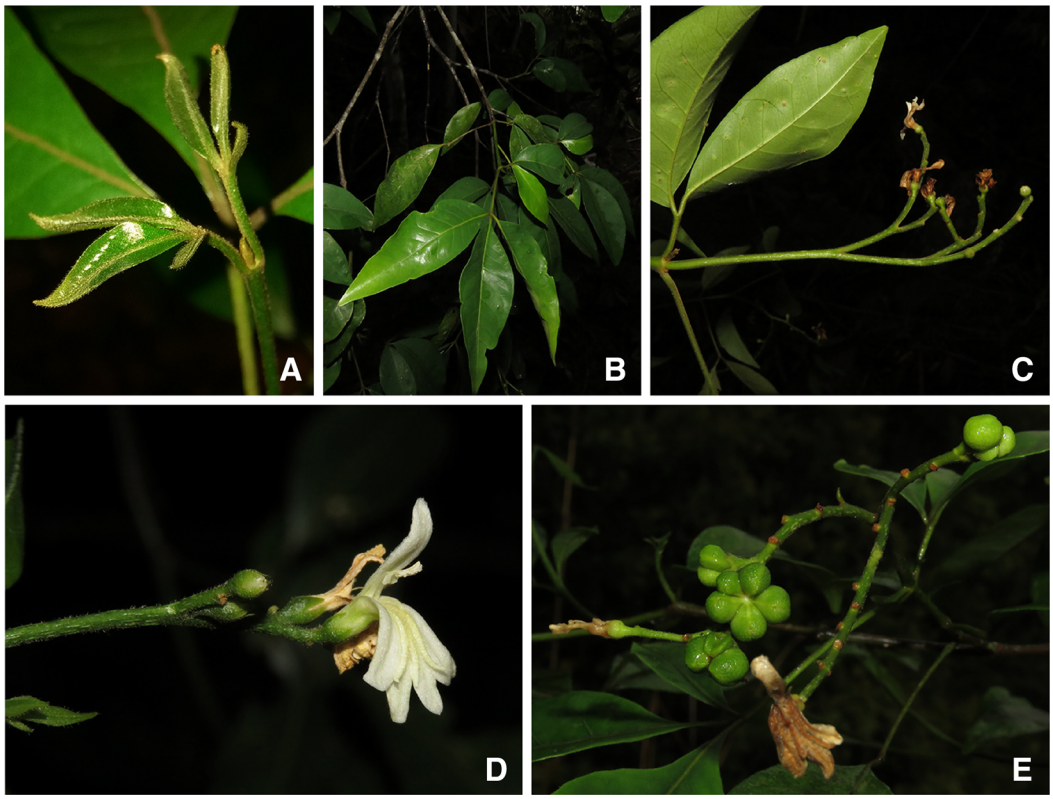

Fig. 2. *Lubaria heterophylla*. **A.** Trifoliolate primordial leaves of which one of the three leaflets is reduced. **B.** Detail of leaves and branches. **C.** Inflorescence with senescent flowers. **D.** Flower, lateral view. **E.** Immature fruits (some with underdeveloped cocci) and senescent flowers. (A from cultivated young plant; B–C from *Trujillo & Londoño 14*; D from *Londoño & Trujillo 240*; E from *Trujillo & Londoño 15*. Photos by Y. Londoño, edited by Diego A. Zapata Z., HUA illustrator.)

43) flowers, the axes villous; monochasial branches 3.9–38.5 (–83.3) mm long, villous; bracts ca. 0.5 mm long, deltoid, villous; bracteoles 0.5–1 mm long, lanceolate, villous; pedicels 1–3 mm long, villous-strigose. *Calyx* imbricate-quincuncial in bud, the 2 outer sepals 1.5–1.9 × 1.2–1.7 mm, the 3 inner sepals 1.5–1.9 × 0.8–1.2 mm, all 5 ovate to elliptic, villosulous adaxially and villous-strigose abaxially with whitish trichomes, ciliate, sparsely to densely glandular-punctate. *Corolla* bilabiate, 9–11.5 mm long, white, adaxially lanuginose from 1 to 6 mm from the base and hispid to hispidulous on the rest of the surface, glandular-punctate (dark punctate when dry); the minor lip 9–11.2 × 2–3 mm, obovate, attenuated unguiculate, rounded to acute at apex; major lip 9–11.5 × 4–6 mm (width measured under the insertion of the lobes), widely obovate, 4-lobed, the lobes 2–5.2 × 1.2–3.5 mm, rounded to acute at apex; lips free from each other at base and coherent from ca. 1.5 mm to ca. 4 mm from the base, adherent to the filaments and staminodes by intertwining of trichomes on their adjacent surfaces. *Androecium* of 2 fertile stamens and 3 staminodes; fertile stamens flanking the minor lip, the filaments 6–6.5 × ca. 1 mm, widening up to 4 mm from the base, distally attenuate, free from each other at base and connate from ca. 1.5 mm to 4.5 mm from the base, adherent to the corolla by a lanuginous zone from 1 to 4.5 mm from the base; the staminodes 10.2–11 × ca. 1 mm, linear, densely hirsute adaxially, adherent by abaxial hirsutulous indumentum to the major lip from 1 to 5 mm from its base; anthers basifixed, 2.5–4 × ca. 1 mm (including basal appendage), obliquely oblong, laterally coherent along their adjacent margins, glabrous, occasionally with sparse trichomes, the

connective eglandular, blunt at apex. *Disc* 1–2 mm high, cupular, inflexed, costate, shortly 5-lobed at margin, ceraceous, enclosing the ovary. *Ovary* of 5 free carpels with 2 ovules each, glabrous, the surface alveolate; style 6–8 mm long, curved, glabrous; stigma capitate, 5-lobed. *Fruit* (immature) with up to 5 dehiscent cocci, each 5 mm long, these ovate to obovate, acute at apex, glandular-punctate, rugose, glabrous, 1-seeded. *Seed* not seen.

Distribution and habitat.—Known from a single population of about 30 individuals growing on the bank of the lower course of a creek locally known as Quebrada El Recreo (a tributary of Río Ité), an area located in the eastern part of the municipality of Remedios, Antioquia department (Fig. 3). The climate of this area corresponds to equatorial monsoon (Am) under the Köppen-Geiger climate classification (Kottek et al., 2006) with average year-round temperatures between 24 °C and 26 °C, 2500–3000 mm of annual precipitation and a marked dry season from December to March (IDEAM, 2017). Individuals were mostly found in shaded places of the understory or below the canopy of mature trees and appeared to prefer rocky calcareous and sandy soils under the influence of supplementary humidity from the watercourse around where they grow.

Phenology.—Flowering and fruiting in March and April.

Etymology.—*Lubaria* is based on the vernacular name "lúbaro" cited in the protologue of *L. aroensis* (Pittier, 1929), and *heterophylla* is derived from the Greek, "heteros-" (different) and "phúllon" (leaf), in reference to the presence of leaves with different sizes and number of leaflets on the same shoot in mature plants.

Conservation status.—Based on the apparently restricted distribution (EOO < 100 km^2, AOO < 10 km^2, habitat fragment < 500 km^2, and the small number of individuals recorded), and the almost completely deforested landscape surrounding the riverine zone of the creek where they grow, this species should be classified as critically endangered (CR) according to the criteria B1ab(iii)+B2 of the IUCN V 3.1 (IUCN, 2012).

Taxonomic notes.—Although the two species of *Lubaria* share similar flowers and fruit, *L. heterophylla* can be distinguished from the only previously known species, *L. aroensis*, most readily by its leaves and corollas. In *L. heterophylla*, the leaves are palmately trifoliolate (rather than simple like those of *L. aroensis*), and one of a pair of mature leaves at a node has a shorter petiole, slightly smaller leaflets which frequently are reduced to two or one (and looking like a simple leaf). In both species, the corolla is bilabiate, with a minor lip of one petal and a major lip of four connate petals. In the new species, the major lip is tightly coherent to the minor lip (rather than free from it as in *L. aroensis*). The coherence occurs very near the base of the corolla by "capillinection" (Weberling, 1989: 48), i.e., the intertwining of dense pubescence on the overlapping margins of the major and minor lips. *Lubaria heterophylla* further differs from *L. aroensis* by its smaller height (shrub or tree to 6 m tall vs. tree 4–12 m tall), smaller calyx 1.5–1.9 (vs. 3–4) mm long, smaller corolla 9–11.5 (vs. 13–16) mm long, and apically blunt (vs. apiculate) anther connective.

Additional specimens examined. COLOMBIA. Antioquia: Mun. Remedios: vereda Río Negrito, quebrada El Recreo, 6°54′19.13″N, 74°28′25.73″W, 360 m, 1 Apr 2017 [im fr], *Y. Londoño & A. M. Trujillo 80* (MEDEL); 6°54′18,06″N, 74°28′29.40″W, 365 m, 2 Apr 2017 [fl & fr], *Y. Londoño & A. M. Trujillo 84* (MEDEL); 6°53′57.57″N, 74°29′14.66″W, 350 m, 5 Mar 2018 [fl], *Y. Londoño & J. A. Pérez 217* (HUA, JAUM, MEDEL, SPFR); 6°54′19.84″N, 74°28′26.69″W, 350 m, 5 Mar 2018 [fl], *Y. Londoño & J. A. Pérez 237* (COL, HUA, MEDEL); 6°54′18.65″N, 75°31′30.78″W, 350 m, 5 Mar 2018 [bud, fl], *Y. Londoño & J. A. Pérez 238* (HUA, SPFR); 6°54′18.65″N, 74°28′29.22″W, 350 m, 6 Apr 2018 [fl], *Y. Londoño & A. M. Trujillo* 240 (COL, CUCV, FAUC, HUA, JAUM, MEDEL, SPFR); 6°53′55.04″N, 75°30′39.93″W, 350 m, 6 Apr 2018 [fr], *Y. Londoño & A. M. Trujillo 256* (HUA, NY, SPFR); 6°54′19.84″N, 74°28′26.69″W, 350 m, 6 Apr 2018 [fl], *A. M. Trujillo & Y. Londoño 014* (COL, CUVC, FAUC, HUA, JAUM, MEDEL, MO, NY, SPFR); 6°53′57.57″N, 74°29′14.66″W, 350 m, 6 Apr 2018 [fr], *A. M. Trujillo & Y. Londoño 15* (COL, HUA, MEDEL).

The new species clearly belongs to *Lubaria*, which can be distinguished from other genera in Galipeinae by the combination of opposite leaves, a terminal several-times-branched dichasial inflorescence, calyx with two sepals slightly wider than the other three, a bilabiate corolla with a minor lip of one petal and a major lip formed by four connate petals, filaments of fertile stamens connate along adjacent margins, anthers with basal appendages and glandular punctate on the abaxial surface (but not in the connective), and ovary of free

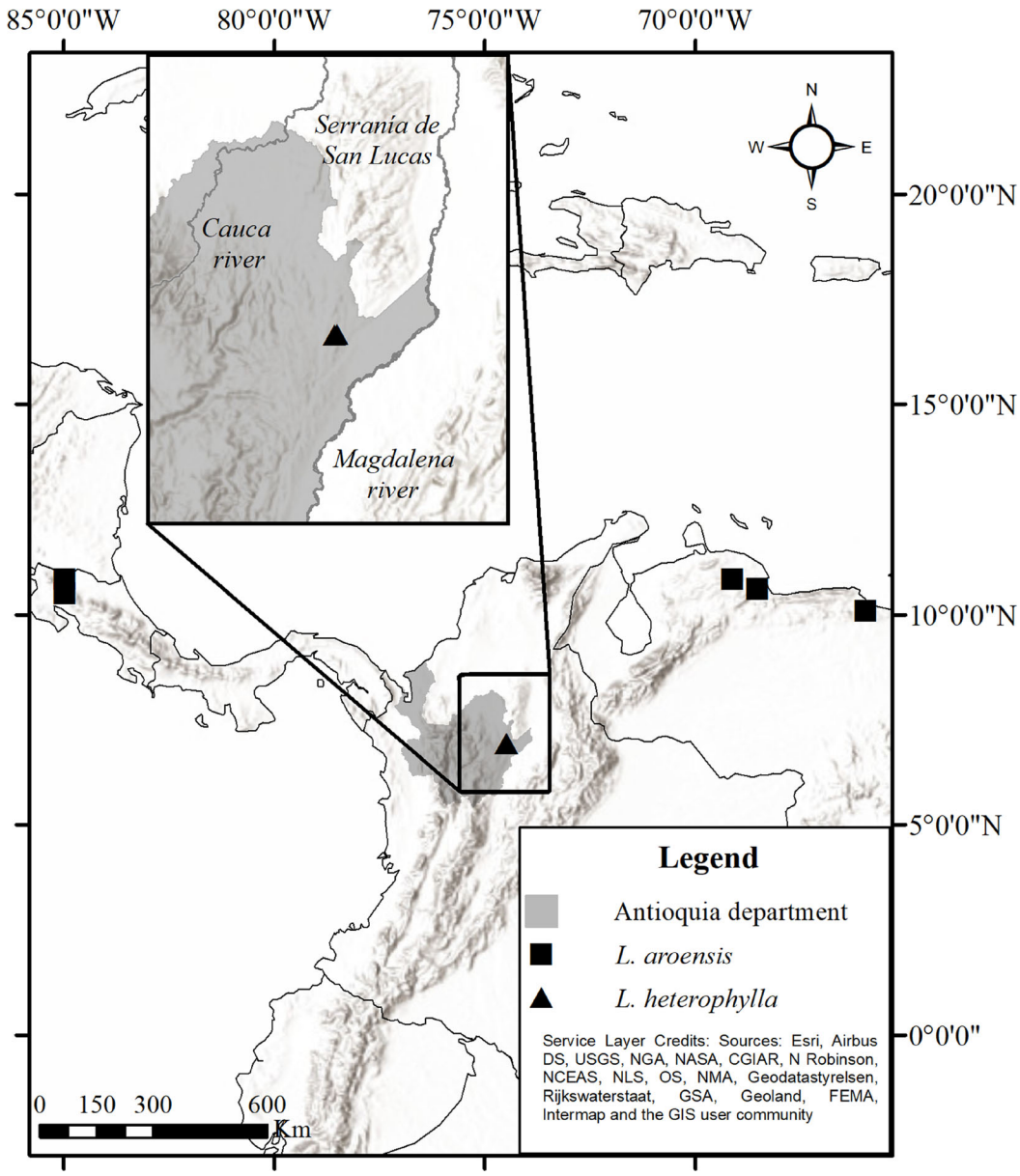

Fig. 3. Distribution of *Lubaria*.

carpels that form a fruit of 1 to 5 dehiscent follicles.

The most remarkable difference between the new species and *Lubaria aroensis* is the presence of trifoliolate leaves but with concurrent variation of petiole length, leaflet size and leaf composition within a single individual, a condition that can be defined as heterophylly (Zotz et al., 2011). Observations of cultivated young plants showed that all primordial leaves had three leaflets but slightly unequal petioles, and generally both at a node mature as trifoliolate (Fig. 2A). However, in adult individuals in the field, the leaves with the shortest petiole at a node, were frequently either

bifoliolate or simple, with smaller leaflets than the trifoliolate ones and without apparent basal abscission leaflet scars. This pattern of variation suggests that the reduction in number of leaflets could happen by a mechanism of either discretionary suppression of leaflet formation or early abortion and shedding of one or two lateral leaflets during leaf expansion. These leaf alterations eventually would cause an overall reduction in leaf area, which could result in a limitation of the amount of transpiration. The observation of mostly pairs of trifoliolate leaves in the young cultivated individuals which were watered and shaded, in contrast with more reduced leaves in individuals growing in the natural range (an area subject to an annual four-month period of elevated temperature and reduced rainfall) may suggest a connection between these post-developmental changes in the leaves and the environmental water stress in the vegetation of the area during the dry period. Consequently, the leaf structure alteration recorded in *L. heterophylla* could be a form of phenotypic plasticity in response to environmental conditions and then also comply with the original definition of heterophylly (Nakayama et al., 2017; Zotz et al., 2011). This leaf variation also could be alternatively explained as an architecturally related adjustment of the pair of leaves at each node to improve the sunlight exposure efficiency when the plant crown is becoming denser. Further field observations and long-term monitoring of growing individuals may help to confirm details of the leaf development and to explain this case of heterophylly.

This is the first report of *Lubaria* for Colombia and as suggested by the also restricted occurrences of *L. aroensis*, individuals of the genus seem to be limited to riparian lowland tropical forest. *Lubaria heterophylla* is only known from about 30 individuals in the riverine habitat of a small creek (in an area less than 10 km^2) with copious calcareous rock outcrops in the north (eastern side) of the central branch of the Colombian Andes. Much of the forest in this region has been cleared, and our searches for this species in nearby forest relicts away from the river were unsuccessful. Similarly, all the collections (including the type) of *L. aroensis* with geographic data in the online database Tropicos.org (2019) are cited as riparian. Further studies of soil properties and other environmental variables may help to determine whether narrow microhabitat preferences can explain the disjunct and highly restricted current distribution. In addition, population biology studies and field surveys of both species are needed to assess appropriate conservation measures. In the perspective of contributing to the evolutionary knowledge in the family, further molecular phylogenetic and anatomical studies of Galipeinae including *Lubaria* (complementing those by Groppo et al., 2017 and El Ottra et al., 2013, 2019, respectively) would help to refine the understanding about the origin of zygomorphic flowers in Rutaceae.

Finally, with the discovery of *Lubaria* in Colombia, a country with a diverse geography and still many botanically unexplored areas, new records of one or both species of the genus might be found in parts of the country near the known locality of *L. heterophylla* in the valley of the Magdalena River and/or situated between it and those of *L. aroensis* in northern Venezuela (Coastal Cordillera in the states of Miranda and Falcón) and northwestern Costa Rica (provinces of Guanacaste and Alajuela). Given the relative rarity of opposite leaves and bilabiate corollas in neotropical Rutaceae, unidentified herbarium specimens of *Lubaria* could also remain misfiled in other families as Pittier (1929) reported.

Acknowledgments

We thank Irley Andrea Barrientos and her family and Miguel Rene Guzmán for assistance with the fieldwork; Juan Camilo Sánchez, Daniel Mauricio Díaz, Álvaro Idárraga, and Juan Pablo Tobón for help to handle and process herbarium material; Adriana María Sanín (HUA) and Diego Armando Zapata (HUA) for the wonderful illustrations and editing of photographs; Milton Groppo for his taxonomic advice and feedback, Jacquelyn A. Kallunki for her editorial and taxonomic advice and suggestions on the manuscript; and herbarium curators Felipe Cardona and Francisco Javier Roldán (HUA), Jorge Mario Vélez (MEDEL), and Norberto López and Álvaro Cogollo (JAUM) for access to collections, equipment, and general advice.

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