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Lepanthes zygicola (Orchidaceae: Pleurothallidinae), a new species from northeastern Cordillera Volcánica Central, Costa Rica

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Summary. *Lepanthes* is a diverse Neotropical genus within the Orchidaceae and a significant component of Costa Rica's orchid flora. Despite extensive taxonomic studies, an ongoing need persists to explore and document the diversity of *Lepanthes* in unexplored regions of the country, such as the Cordillera Volcánica Central and Braulio Carrillo National Park. This study describes and illustrates a new species, *Lepanthes zygicola*, discovered on the Caribbean slope of Costa Rica within the ecotourism farm "Finca Jungla Paraíso," adjacent to Braulio Carrillo National Park. The new species exhibits distinct characteristics, including slightly convex, ovate leaves, shorter inflorescences remaining on the abaxial side of the leaf, larger pedicels, glabrous entire-margin sepals and pink-red proximal petals transitioning to amber distally, along with a ciliate lip apex. These features distinguish *L. zygicola* from its most similar species, *L. ingramii* and *L. subdimidiata*. The discovery of *L. zygicola* highlights the botanical richness of the Cordillera Volcánica Central and encourages further exploration in similar regions to unveil potentially undiscovered species. It also advocates for floristic and conservation initiatives to protect these unique orchid populations in their natural habitats, contributing to the broader understanding of orchid diversity in the country.

Key Words. Biodiversity, Braulio Carrillo National Park, taxonomy.

Introduction

The genus *Lepanthes* Sw., with over 1203 accepted species, is one of the most diverse within the subtribe Pleurothallidinae Lindl. ex G.Don., and one of the largest genera in the Orchidaceae (Pupulin & Bogarín 2012; Bogarín *et al.* 2019b; POWO 2024). This genus ranges from southern Mexico to Bolivia, Peru, northern Brazil and the Antilles (Luer & Thoerle 2012), with most species concentrated in the montane forests of the tropical Andes and Central America (Bogarín *et al.* 2016; Pérez-Escobar *et al.* 2017).

In Costa Rica, the most recent taxonomic treatment of *Lepanthes* was conducted by Luer (2003), which identified 93 species. Subsequent research has revealed several new species, either from previously unexplored areas or from taxonomic studies focused on specific groups of Neotropical orchid taxa (Pupulin & Bogarín 2010). This has elevated the species count for the country to over 150 in recent years (Bogarín *et al.* 2020; Bogarín & Kisel 2014; Chinchilla *et al.* 2020; Pupulin & Bogarín 2011; 2012; Pupulin *et al.* 2023). However, current diversity assessments for *Lepanthes* likely still underestimate the actual number of species in the country. This underestimation may be attributed to the rapid and recent diversification of the genus, which exhibits the highest speciation rates in the Orchidaceae, particularly in southern Central America (Pérez-Escobar *et al.* 2024), coupled with high levels of endemism, the specific habitat preferences of several species, small effective population sizes and restricted gene flow (Tremblay & Ackerman 2001; Pérez-Escobar *et al.* 2017). For instance, some species are known solely from their type locality and these populations are often limited to a few individuals in restricted areas or specific habitat conditions, such as the base of trees in the understory or twigs within dense tree canopies (Pupulin & Bogarín 2012). Consequently, many unexplored sites could harbour numerous yet-to-be-identified species.

The highest species concentration in Costa Rica is found in premontane and montane cloud forests, between 1000 and 2500 m of elevation. However, species diversity sharply declines in tropical humid lowland forests below 1000 m, with only about 36 known species (Bogarín *et al.* 2020; Bogarín & Kisel 2014; Chinchilla *et al.* 2020). Recent discoveries have

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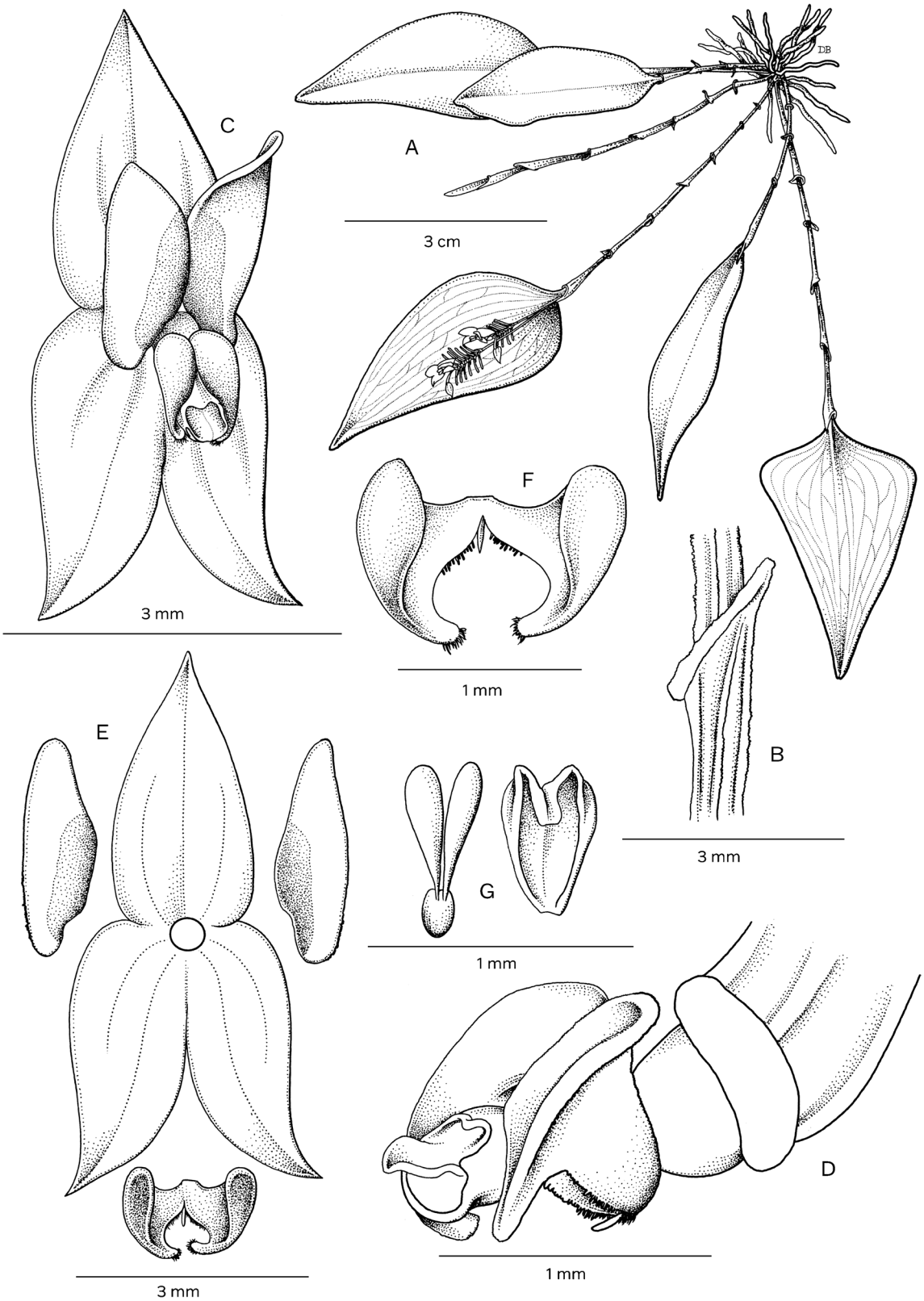

Fig. 1. *Lepanthes zygicola*. **A** habit; **B** ramicaul; **C** flower; **D** ovary, column and lip, lateral view; **E** perianth, flattened; **F** lip, flattened, front view; **G** pollinarium and anther cap. From *L. Álvarez* 551. DRAWN BY D. BOGARÍN.

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added three species from lowland tropical humid forest habitats, two from the Caribbean lowlands, *Lepanthes adenophora* Bogarín, M.Cedeño & Chinchilla and *L. crucitasensis* Chinchilla, M.Cedeño & Bogarín and one from the Pacific in Osa Peninsula, *L. osaensis* Chinchilla, Aguilar & Bogarín (Bogarín *et al.* 2020; Chinchilla *et al.* 2020).

Historically, numerous localities within the Cordillera Volcánica Central on the Caribbean slope of Costa Rica remain botanically unexplored. A notable example is the Braulio Carrillo National Park, which spans over 47,689 hectares of pristine forest and safeguards over 6,000 plant species. The park's varied terrain starts at 150 m of elevation near Estación Biológica La Selva and peaks at 2906 m, including the summits of Barva and Cacho Negro volcanoes. The region receives an annual rainfall ranging from 2500 – 5734 mm. The intricate structure of the vegetation, coupled with the rugged topography, makes botanical exploration particularly challenging (Timm *et al.* 1989; Hammel *et al.* 2002). However, the park is abundant in suitable habitats for various orchids, notably those within the Pleurothallidinae subtribe (Bogarín & Karremans 2016). Previous contemporary expeditions to these areas have led to the discovery of new orchid species (Luer 1992; Bogarín & Kisel 2014) and other angiosperms (Taylor *et al.* 2011; Zamora 2013; Santamaria-Aguilar & Lagomarsino 2015; Kuethe *et al.* 2023; Hammel *et al.* 2002).

During a recent exploration of the Caribbean slope of Costa Rica, an undescribed species of *Lepanthes* was discovered growing on the understory twigs of *Zygia unifoliolata* (Benth.) Pittier. This paper describes and illustrates this newly discovered species, collected in the lowland forest of the ecotourism farm "Finca Jungla Paraíso", located on the edges of the Braulio Carrillo National Park on the Costa Rican Caribbean slope.

Materials and Methods

Plants were collected in September 2021 from the lowland forest of the "Finca Jungla Paraíso" ecotourism farm, located in Vara Blanca, Heredia, at coordinates 10.1862 N, 83.9490 W. The farm is located on a piedmont with elevations between 300 – 700 m on the Caribbean slope of Costa Rica. These specimens were later cultivated at Jardín Botánico Lankester, University of Costa Rica (JBL). Flower documentation was performed with a Nikon® D7100 camera, while detailed botanical sketches were produced using a Leica® MZ 7.5 stereomicroscope with a drawing tube. These illustrations were digitised and compiled into a composite plate with Adobe Photoshop CS6®. Further detailed botanical sketches in black and white were created using an Apple Pencil® in the Procreate application (https://procreate.com/) on an iPad Pro® tablet (Apple Inc.), with file dimensions set at 8.5 × 11 inches and a resolution of 800 dpi (Bogarín *et al.* 2019a; Bogarín *et al.* 2020; Chinchilla *et al.* 2020). Stippling and shading were added to a printed version of the sketch with a 0.1 mm Rotring rapidograph®. For photography, a Nikon D850 camera paired with a Nikon AF-S DX NIKKOR 18 – 105 mm f/3.5 – 5.6 G ED macro lens was used. Species descriptions and comparisons relied on both wild-collected and cultivated specimens, enriched by illustrations and protologues. For previously described species, only their protologues were referenced. Acronyms of the herbaria mentioned in

Fig. 2. Photo of *Lepanthes zygicola* from the plant that served as the holotype.

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this work are according to Thiers (2024). Plant terminology adheres to Stearn (1992), Beentje (2016) and Luer & Thoerle (2012). The map was created using QGIS 3.30 (https://qgis.org/pt_BR/site/) with ESRI (https://www.esri.com/en-us/home) Shaded Relief basemap and georeferenced occurrences from the JBL herbarium. The conservation status was assessed following IUCN (2022) guidelines. The Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated using a 2 km × 2 km grid from geographical data from the specimens in the Geospatial Conservation Assessment Tool (GeoCAT, http://geocat.kew.org, Bachman *et al.* 2011).

Taxonomic Treatment

Lepanthes zygicola *Bogarín, L.Álvarez, R.Barboza & J.J.Pacheco,* **sp. nov.** Type: Costa Rica. Heredia, cantón Heredia, Distrito Vara Blanca, Finca Jungla Paraíso, sendero norte, 10°11'10.4"N, 83°56'56.5"W, 525 m, disturbed primary forest, with representative species of trees such as *Zygia unifoliolata, Vochysia allenii, Carapa guianensis, Virola koschnyi, Couepia janzenii*, 21 Sept. 2021, *Leonardo Álvarez* 551, with *Josué Pacheco Quesada, Gared Rodríguez-Barboza & Allan Brenes* (holotype JBL!; isotypes CR!, USJ!). Figs 1, 2 & 3C.

http://www.ipni.org//urn:lsid:ipni.org:names:77355270-1

Plant an *epiphytic herb*, caespitose, suberect, up to 8 cm tall. *Roots* filiform, flexuous, to 0.5 mm in diam. *Ramicauls* slender, suberect, 1.0 – 6.5 cm long; enclosed by 6 – 9 adpressed, ribbed, minutely ciliate-muricate, lepanthiform sheaths, dilated at the apex into an obliquely lanceolate, acuminate ostia, ciliate along the margins. *Leaves* ovate, subcoriaceous, slightly convex, dark green on the adaxial surface, purple on the abaxial surface, reticulate, with green veins, 2.2 – 4.5 × 1.0 – 2.3 cm, cuneate, contracted into a short conduplicate petiole, attenuate towards the apex, acute, with the tip of the central vein protruding abaxially within the sinus. *Inflorescence* produced on the abaxial side of the leaf, racemose, distichous, glabrous, shorter than the leaves, successively flowered, peduncle filiform 0.8 – 2.0 cm long, covered with two tightly adpressed, lanceolate, acute bracts, rachis fractiflex, to 0.7 cm long. Floral bracts lanceolate, muriculate, acuminate, conduplicate, membranaceous, 0.8 mm long. Pedicels terete, 4 mm long, persistent. *Flowers* 6 mm in diam.; ovary terete to 2 mm long, angulate, glabrous; sepals pale yellow-orange; petals pink-red proximally, amber towards the apex, sometimes with the tip of the apex pink-red, lip peach orange; column red-violet. *Dorsal sepal* ovate, acute, 3-veined, 3.4 × 1.8 mm, dorsally carinate-denticulate, connate to the lateral sepals for about 0.5 mm. *Lateral sepals* ovate-lanceolate, subfalcate, 2-veined, acute, connate at the base for 1.2 mm, 3.3 × 1.3 mm. *Petals* transversely bilobed, cellular-pubescent, 0.9 × 2.8 mm, erect; upper lobe oblong-ovate, obtuse, 0.9 × 2.2 mm; lower lobe suborbicular, subfalcate, 0.5 × 0.7 mm. *Lip* bilobed, adnate to the column; lobes ovate,

Fig. 3. Comparison of flower morphology of **A** *Lepanthes ingramii* (JBL s.n., JBL); **B** *L. subdimidiata* (*D. Bogarín* 14771, JBL); **C** *L. zygicola* (preserved as *L. Álvarez* 551, JBL). PHOTOS: D. BOGARÍN.

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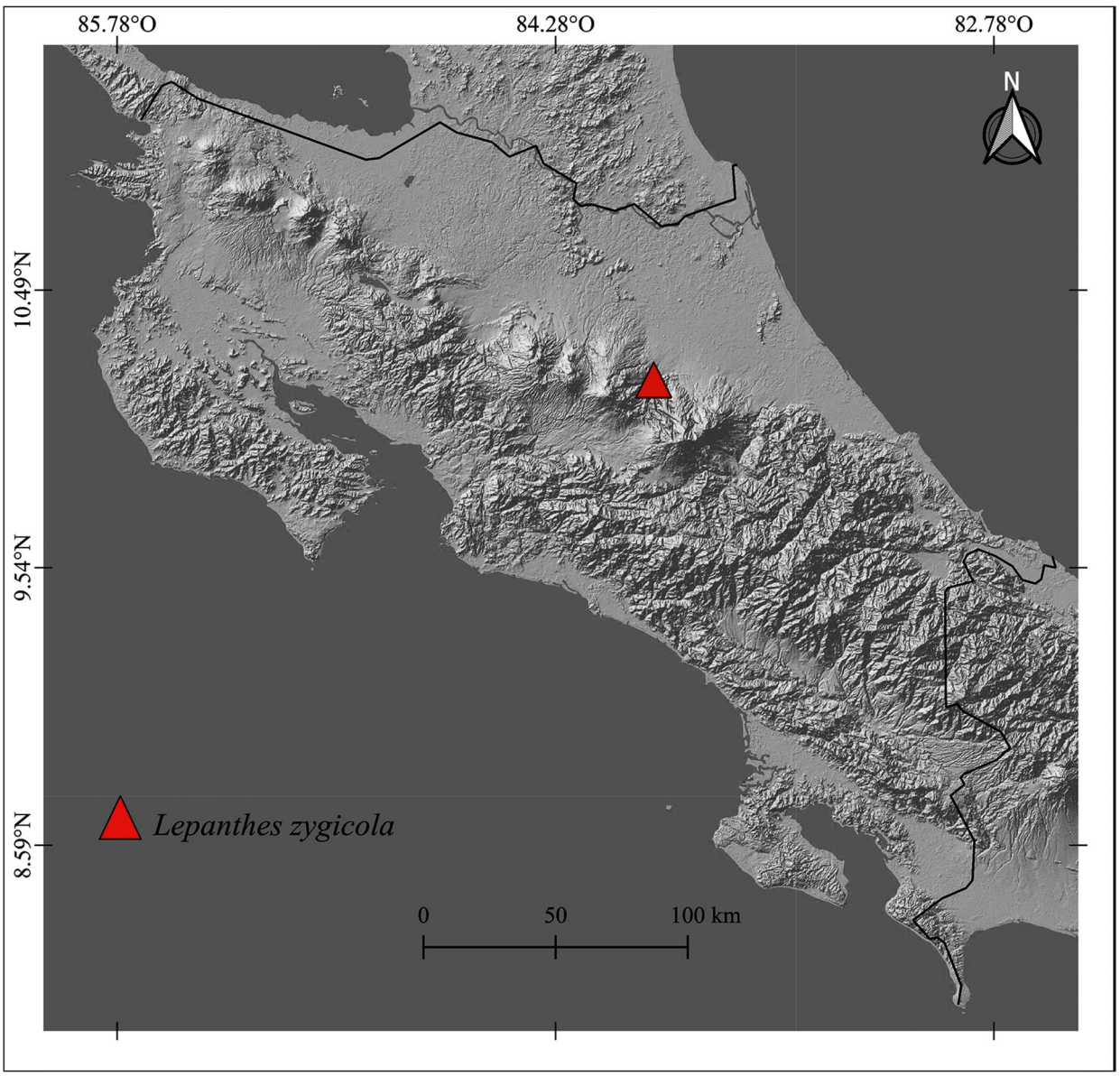
rounded at the base, apices falcate, rounded, ciliate, 0.7 × 0.9 mm; middle margin encircling the column; body reduced, oblong; connectives to 0.5 mm, ciliate at the base, obovate, attenuate towards the base, appendix triangular, acute, glabrous. *Column* terete, broadened at the apex, to 1 mm long, anther dorsal and stigma apical. *Anther cap* cucullate, triangular, 2-celled, to 0.5 mm. *Pollinia* 2, obpyriform, basal portion attenuate, viscidium rounded, yellowish, apical.

RECOGNITION. *Lepanthes zygicola* can be distinguished by a combination of key morphological characteristics, such as the slightly convex, ovate leaves abaxially purple with reticulate green veins; inflorescences shorter than the leaves and remaining on the abaxial side of the leaf; glabrous, entire sepals and petals with the upper lobe oblong-ovate, obtuse, suberect, divergent, the lower lobe orbicular, significantly smaller than the upper lobe, pink-red proximally and amber distally. The lip features ovate blades with a ciliate apex and a filiform appendix. This species shares morphological similarities with *L. ingramii* Luer and *L. subdimidiata* Ames & C.Schweinf. (Fig. 3), but it can be set apart by its unique traits: inflorescences remaining on the abaxial side of the leaf (as opposed to the adaxial side in *L. ingramii* and *L. subdimidiata*); larger pedicels to 4 mm (compared to 0.75 – 1.5 mm); sepals entire, divergent, the lower lobe suborbicular



Map 1. Distribution map of *Lepanthes zygicola* based on field collection.

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(rather than denticulate, ovate, triangular, the lower lobe triangular or oblong); lip blade with a ciliate apex (vs glabrous) and a conspicuously triangular, acute appendix (vs inconspicuously filiform or ciliate, respectively).

DISTRIBUTION. Central America: Costa Rica. This species is known exclusively from the eastern Heredia Province (Map 1).

HABITAT AND ECOLOGY. The plants inhabit tropical moist forests, specifically in the transition zone of the premontane belt on the Caribbean slope of the Cordillera Volcánica Central, situated at approximately 525 m elevation. They grow epiphytically on the apical twigs of *Zygia unifoliolata* (Fabaceae) in partial shade in disturbed primary vegetation.

CONSERVATION STATUS. This species has only been identified at the type location, with no current information on its broader population. Both its AOO and EOO are 4 km^2. It is protected within the private reserve of Finca Jungla Paraíso, situated adjacent to Braulio Carrillo National Park. Despite being found in a private reserve and identified in just one location, with an AOO under 20 km^2, there is no evidence to suggest ongoing threats or a decline in its habitat. Using the D2 criteria, this species is, therefore, provisionally assessed (IUCN 2022) as Vulnerable [VU D2]. However, a comprehensive assessment is recommended once more investigation has occurred in surrounding areas. By describing *Lepanthes zygicola*, we aim to encourage further conservation efforts for its protection.

PHENOLOGY. Specimens were collected in bloom in September in the wild. In cultivation, flowering has been observed from April to November.

ETYMOLOGY. The specific epithet combines the name of genus *Zygia* P.Browne (Fabaceae) with the suffix '-cola', meaning 'dweller'. This is used as a noun in apposition, referring to the habitat where the species was first discovered, growing on the twigs of *Zygia unifoliata*.

NOTES. *Lepanthes zygicola* resembles *L. ingramii* and *L. subdimidiata*. Their vegetative characteristics are similar, and all three species are found in mid-elevation areas of the Caribbean slope of Costa Rica and share similar habitats. The new species can be differentiated from *L. subdimidiata* by its mostly suberect habit (as opposed to pendant in *L. subdimidiata*); inflorescences remaining on the abaxial side of the leaf (vs the adaxial side); pedicels longer, 4.0 mm (compared to 1.5 mm); glabrous sepals (instead of denticulate); dorsal sepal larger, 3.4 mm (vs 2.7 mm); upper lobe of the petals bigger, 0.9 × 2.8 mm (compared to 0.7 × 1.6 mm), bilaminate lip bigger, 0.7 × 0.9 mm (compared to 0.4 × 0.6 mm) and the ciliate lip apex (instead of glabrous). Compared to *L. ingramii*, it can be separated by the purple leaves with green reticulate veins; the inflorescences remaining on the abaxial side of the leaf (vs adaxial side in); pedicels longer, 4.0 mm long (vs 0.75 – 1.5 mm); glabrous sepals (vs denticulate); dorsal

Table 1. Morphological and distributional comparison of *Lepanthes zygicola*, *L. subdimidiata* and *L. ingramii*.

Characters	*L. zygicola*	*L. ingramii*	*L. subdimidiata*
Elevation (m)	525	750	650 – 1000
Leaf abaxial colour	purple with green veins	green or purple	purple with green veins
Inflorescence position	abaxial side of the leaf	adaxial side the leaf	adaxial side of the leaf
Pedicels (mm)	4.0	0.75 – 1.5	1.5
Sepals margin	entire	denticulate	denticulate
Dorsal sepal size (mm)	3.4 × 1.8	2.4 × 1.2	2.7 × 2
Dorsal sepal shape	ovate	ovate	broadly ovate
Dorsal sepal apex	acute	acute	acuminate
Lateral sepals size (mm)	3.3 × 1.3	2.3 × 1.3	3.1 × 1.5
Lateral sepals apex	acute	obtuse	acute
Petal, upper lobe (mm)	oblong-ovate, obtuse, suberect, diverging apices, 0.9 × 2.2	oblong, acute, subfalcate, bending forward, converging apices, 0.5 × 1.8	ovate, acute, erect, 0.7 × 1.6
Petal, lower lobe shape	orbicular	triangular	oblong
Petal colour	pink-red proximally, amber towards the apex	red proximally, yellow towards the apex	amber, red proximally and towards the distal
Lip size (mm)	0.7 × 0.9	0.5 × 0.8	0.4 × 0.6
Lip connectives size (mm)	0.5	1.0	0.5
Lip lobes	ovate, embracing the column	oblong, lifted above the column	ovate, embracing the column
Lip position	middle margin encircling the column	margin not encircling the column	middle margin encircling the column
Lip apex	ciliate	glabrous	glabrous
Lip appendix	conspicuously filiform	ciliate	inconspicuously filiform

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sepal larger, 3.4 mm (vs 2.4 mm) and lateral sepals 3.3 mm (compared to 2.3 mm); petals and lip are also bigger, with a longer oblong-ovate, obtuse, upper lobe of the petals, 0.9 × 2.8 mm (compared to 0.7 × 1.6 mm in *L. ingramii*); longer, bilobed lip, 0.7 × 0.9 mm (compared to 0.5 × 0.8 mm); the lip having a ciliate apex (vs glabrous); ovate lip lobes (vs oblong) and the margin of the lip encircling the column (vs not encircling).

Luer (2003) considered *Lepanthes ingramii* to be conspecific with *L. subdimidiata*. However, *L. ingramii* differs by having acute sepals (vs subacuminate, falcate in *L. subdimidiata*); oblong, acute, subfalcate upper lobes of petals that bend forward with converging apices (vs ovate, acute, erect); triangular connectives of the lip that lift the blades above the column (vs oblong, embracing the column) and connectives that protrude downward below the sinus (vs not protruding downward). Therefore, *L. ingramii* is not considered a synonym of *L. subdimidiata* (Pupulin *et al.* 2023). The comparison of these morphologically similar species is detailed in Table 1 and Fig. 3.

Conclusions

The discovery of *Lepanthes zygicola* in the Cordillera Volcánica Central highlights the region's botanical richness in areas such as Braulio Carrillo National Park. Although there has been extensive research on this genus in Costa Rica, we demonstrate that overlooked realms of diversity still remain. The protection offered by private reserves, such as Finca Jungla Paraíso, located adjacent to Braulio Carrillo National Park, combined with continued exploration and conservation, is essential for deepening our understanding of orchid diversity. This study reinforces the importance of ongoing taxonomic and floristic research, as well as conservation priorities, within the Orchidaceae of Costa Rica.

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Declarations

Conflict of Interest The authors declare that they have no conflicts of interest to disclose.

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