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Achlorophyllous Plants of Quindío, Colombia: Holoparasitic and Mycoheterotrophic Species

Plantas Sem Clorofila de Quindío, Colombia: Espécies Holoparasitas e Micoheterotróficas

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Palavras-chave
zonas de vida, não fotossintéticas, parasitismo, saprófitas, simbiose

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Abstract

Achlorophyllous plants comprise heterotrophic lineages that obtain carbon and nutrients through direct parasitism (holoparasitic species) or associations with fungi (mycoheterotrophic species). In the department of Quindío, Colombia, this floristic component has been little studied. The objective of this research was to compile a taxonomic treatment of the achlorophyllous species present in the department. Field surveys were conducted in 12 municipalities across an elevational range of 970–3800 m, encompassing premontane, montane, high Andean, and páramo forests. Field records were complemented by examination of specimens from the Herbarium of the Universidad del Quindío (HUQ) and taxonomic verification using specialized literature. Four families, five genera, and five species were recorded. Species showed differences in elevational occurrence, with *Corynaea crassa* documented at higher elevations and *Helosis cayennensis* mainly at lower elevations. These findings provide a baseline for further ecological, conservation, and floristic studies in the region.

Resumo

As plantas aclorofiladas compreendem linhagens heterotróficas que obtêm carbono e nutrientes por meio do parasitismo direto (espécies holoparasitas) ou de associações com fungos (espécies micoheterotróficas). No departamento de Quindío, Colômbia, esse componente florístico tem sido pouco estudado. O objetivo desta pesquisa foi compilar um tratamento taxonômico das espécies aclorofiladas presentes no departamento. Foram realizados levantamentos de campo em 12 municípios, abrangendo um gradiente altitudinal de 970–3800 m, incluindo florestas pré-montanas, montanas, alto-andinas e de páramo. Os registros de campo foram complementados pelo exame de espécimes do Herbário da Universidad del Quindío (HUQ) e pela verificação taxonômica com base em literatura especializada. Foram registradas quatro famílias, cinco gêneros e cinco espécies. As espécies apresentaram diferenças em sua ocorrência altitudinal, com *Corynaea crassa* documentada em maiores altitudes e *Helosis cayennensis* principalmente em menores altitudes. Esses resultados fornecem uma base para futuros estudos ecológicos, de conservação e florísticos na região.

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Introduction

The plant kingdom is primarily characterized by the ability of plants to produce their own carbohydrates and other organic compounds through photosynthesis, which provide the food and resources required for growth and the development of different plant structures, thereby functioning as autotrophic organisms. Nevertheless, within their extensive diversity (~ 374,000 species), there exist completely heterotrophic and partially heterotrophic species (~ 5,330 species) that depend on other living organisms to obtain the whole or part of nutrients, respectively (Christenhusz & Byng, 2016; Nickrent, 2020; Jąkalski, et al., 2021; Lobo Cabezas, 2022).

Among plants that lack chlorophyll (hereafter achlorophyllous), there are two groups, holoparasites (~390 species) and mycoheterotrophs (~580 species) (Heide-Jørgensen, 2013; Jąkalski et al., 2021; Merckx et al., 2024). The first is characterized by complete dependence on a host plant, from which they obtain the resources necessary for survival, growth, and reproduction through specialized structures called haustoria (Nickrent & Musselman, 2016). The second group does not form haustoria and obtains carbon and nutrients through symbiotic associations with fungi (Krauczuk et al., 2013; Nickrent & Musselman, 2016).

In Colombia, several families of achlorophyllous plants are recognized. These include 19 holoexoparasitic species within the families Balanophoraceae, Cytinaceae, Convolvulaceae, Lennoaceae and Mitrastemonaceae, 3 holoendoparasitic species in Apodanthaceae and 1 holoparasitic species of Orobanchaceae (González & Pabón-Mora, 2023). In the case of holoparasitic groups, six genera and six species of Balanophoraceae have been reported, with *Ombrophytum villamariensis* S. Guzm.-Guzm. representing the most recent record of the family for the country (Guzmán-Guzmán, 2019). Additionally, *Bdallophytum caesareum* (Fern. Alonso & H. Cuadros) Byng & Christenh. is the only species of Cytinaceae recorded in Colombia (Fernández-Alonso & Cuadros-Villalobos, 2012). The family Lennoaceae is also present, represented by *Lennoa madreporoides* Lex., as well as Convolvulaceae with the genus *Cuscuta*, comprising eight species in the country, including both hemiparasitic and holoparasitic forms (Bernal et al., 2016).

Gentianaceae is a diverse family comprising approximately 22 genera and 106 species. Within it, the mycoheterotrophic genera *Voyria*, with eight species, and *Voyriella*, represented in the country solely by *V. parviflora* (Miq.), are recorded. Burmanniaceae, in turn, includes eight genera and 24 species, most of which are mycoheterotrophic and, in some cases, epiphytic. Thismiaceae comprises one genus and three species, with *Thismia andicola* (Aguilar-Cano, S. Guzm.-Guzm. & Lopera-Toro) being the most recently recorded for Colombia (Aguilar-Cano et al., 2023). Triuridaceae encompasses three genera and seven species. Ericaceae is a diverse family in terms of life forms, as it includes trees, shrubs, herbs, epiphytes, and mycoheterotrophic species; the latter are represented exclusively by *Monotropa*, with a single species, *Monotropa coccinea* Zucc. (Plants of the World Online [POWO], 2025). Within Orobanchaceae, a family primarily represented in the country by hemiparasitic species, *Orobanche minor* Sm. is recognized as a heterotrophic species (Fernández-Alonso, 2000; Nickrent & Musselman, 2016).

For the department of Quindío, the families Balanophoraceae, with two species, and Ericaceae (formerly Monotropaceae), with one achlorophyllous species, have been reported (Vargas, 2002). However, no taxonomic studies specifically focused on non-photosynthetic plants have been conducted in the department; consequently, various aspects such as their distribution and ecology remain poorly understood. The objective of this study was to develop a taxonomic checklist and document the spatial and elevational distribution of holoparasitic and mycoheterotrophic plant species in the department of Quindío, based on field sampling and herbarium specimen review.

Materials and Methods

Field surveys were conducted between August 2022 and November 2025 in 12 municipalities of the department of Quindío, Colombia. One-day opportunistic botanical surveys were conducted in each municipality along freely selected routes, covering accessible forest interiors, forest edges, riparian areas, and other suitable habitats for parasitic plants.

Surveys covered premontane forest in Montenegro and La Tebaida; montane forest in Buenavista, Circasia, Filandia, Quimbaya, Córdoba, Armenia, and Génova; and high Andean forest and páramo in Calarcá, Salento, and Pijao, across an elevational range of approximately 970–3800 m. The length of survey routes and search effort were not standardized among localities. Achlorophyllous plants encountered during the surveys were recorded and collected as voucher specimens when appropriate. Collected material was processed according to the protocols established by the Herbarium of the Universidad del Quindío (HUQ).

Field records were complemented by the examination of specimens deposited in the Herbarium of the Universidad del Quindío (HUQ). Taxonomic identification was based on comparison with herbarium specimens and specialized taxonomic literature, including monographs and taxonomic treatments of Balanophoraceae, Burmanniaceae, *Voyria*, and *Voyriella*.

Results

In the department of Quindío, five species of achlorophyllous plants were recorded, representing five genera and four families. Balanophoraceae was the most species-rich family, with *Corynaea crassa* Hook. and *Helosis cayennensis* (Sw.) Rich. ex Spreng., whereas Burmanniaceae, Ericaceae, and Gentianaceae were represented by *Gymnosiphon suaveolens* Urb., *Monotropa coccinea* Zucc., and *Voyria flavescens* Griseb., respectively.

Taxonomic treatment

Balanophoraceae Rich., Mém. Mus. Historia. Nat. 8: 429 (1822), nom. contras.

***Corynaea crassa* Hook. f., Trans. Linn. Soc. London 22(1): 31, 54, t. 13 (1856).** (Figure 1A-D).

Type: —COLOMBIA. near Santa Fé de Bogotá, Jul 1846, *William Purdie*, *s.n.* (Holotype: K000642148 [digital image!]).

Holoparasitic herb, fleshy, with coloration ranging from yellowish-brown to reddish, purple, or dark violet. Haustorial system fleshy and hardened; roots terete, fleshy, red to purple or whitish, with a conical apex forming the haustorium. Tuber sub-spherical to ellipsoid, 4–6 cm long and 4–8 cm wide, often irregularly lobed, with short cylindrical projections; invaginated at the point of contact with the host root. Inflorescence terminal, sub-spherical to ellipsoid or oblongoid, rounded in young stages and becoming oblong at maturity, 3–11 cm long and 2–10 cm in diameter. Bracts or scales hexagonal, peltate; peduncle thickened, 6–10 cm long, emerging from the soil, yellowish to brown or dark purple to reddish. Flowers approximately 0.5–0.8 mm long. Male flowers with perianth tubular at the base, trilobed, 3.5–5 mm long and up to 1 mm wide; lobes ligulate. Stamens 3, with filaments connate forming a tubular column 2.5–6 mm long, adnate to the lower third of the perianth tube; anthers connate in a hexalocular synandrium, with locules arranged longitudinally, ca. 0.8 × 1 mm. At the base of the staminal tube, a short conical structure, ca. 0.8 mm long, is present, interpreted as a rudimentary ovary. Female flowers with perianth 1–1.2 mm long and 0.5–0.6 mm wide. Styles filiform, 1–1.2 mm long; stigma capitate. Fruits not observed.

Specimens examined: COLOMBIA. Quindío, Calarcá: corregimiento Planadas, finca La Merced, 3100 m, 4/X/2019, 04°22.3'3.21"N, 73°54'8.39", *A. F. Orozco C.*, 1032 (HUQ!). **Pijao:** Páramo de Chilí, interior de bosque, 3730 m, 4°15'25.0"N 75°37'55.0"W, 8/XI/2025, *A. Marulanda A.* & *L. Álvarez R.*, 115 (HUQ!). **Salento:** Camino estación biológica Estrella de Agua al páramo de Frontino, 3180-3600 m, 21/VI/1994, *M. C. Vélez et al.* 4110 (HUQ!); Camino estación biológica Estrella de Agua al páramo de Frontino, 3180-3600 m, *M. C. Vélez et al.* 4059 (HUQ!); Reserva Acaime, 2800 m, V/1998, *W. G. Vargas.* 4559 (HUA!).

***Helosis cayennensis* (Sw.) Rich. ex Spreng., Syst. Veg., ed. 16 [Sprengel] 3: 765 (1826).** (Figure 1E-H)

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Type: —FRENCH GUIANA. 1784-1789, *Louis C. M. Richard - s.n.* (isolectotype: P05349653 [digital image!]).

Holoparasitic herb, fleshy, monoecious, 8–30 cm tall, with an overall brown to reddish-brown or dark brown coloration. Root haustorium fleshy, hardened, subglobose to irregular, 1–3 cm long, invaginated at the point of contact with the host root. Rhizome horizontal, elongated, cylindrical, 1.2–15 cm long and ca. 0.2–1 cm in diameter, orange to reddish, reddish-brown, or yellowish, with a smooth surface. Inflorescence terminal, solitary, ovoid to ellipsoid, 1.6–5.6 cm long and 2–5 cm wide, borne on an erect peduncle emerging from the rhizome, cylindrical, fleshy, glabrous to slightly puberulent in the apical portion, 3–23 cm long and 1–3 cm in diameter, brown to grayish-brown; base frequently surrounded by a volva like sheath or by scales forming a ring. Bracts numerous, conical to hexagonally peltate; shield 1–6.5 mm in diameter and 1–3 mm thick, flat or with a central conical protuberance. Male flowers numerous, tubular, 0.5–2.5 mm long, yellow to bright yellow or pale pink; perianth tubular, trilobed; lobes ovate, concave, valvate, 1.8–2.5 mm long and 0.8–1.5 mm wide. Stamens 3; filaments 0.4–3.5 mm long, basally united up to three-quarters of their length forming a column; synandrium spheroidal to cylindrical, 0.5–1.1 mm in diameter; anthers basifixed, ovate to cordate. Female flowers naked or with a highly reduced perianth, 1.2–2.1 mm long; perianth segments inconspicuous, ovoid to flattened. Fruit obovoid, slightly flattened.

Specimens examined: COLOMBIA. Quindío, Armenia: vía Armenia a Pueblo Tapao a borde de quebrada, 4°31'15.9"N, 75°44'59.2"W, 1200 m, 16/II/2023, *A. Marulanda A. & V.D. Ocampo R.*, 44 (HUQ!). **Calarcá:** Vereda Quebrada Negra, Bosque intervenido, 1500-1600 m, 9/X/1994, *C. Vélez, et al.* 4487 (HUQ!). **Filandia:** Riberas río Barbas, sitio El Salao, límites entre Risaralda y Quindío, 12/VII/1985, *G. Arbeláez S. et al.* 946 (HUQ!). **Salento:** Vereda Cocora, Reserva Natural Acaime, 2800 m, 19/IX/1992, *D. Macias P.*, 10 (HUQ!). **Quimbaya:** Vereda La Soledad, finca El Perú, borde de guadual, 1340 m, 26/IX/1996, *C. Vélez et al.* 6363 (HUQ!); vereda El Banidario, finca La Unión, orilla río Buenavista, en guadual, 1230 m, 5/IX/1996, *M. C. Vélez, et al.* 6210 (HUQ!). **La Tebaida:** Valle de Maravélez, 1100 m, 28/II/1993, *D. Macias & J.C. Hincapié*, 81 (HUQ!).

Burmanniaceae Blume, Enum. Pl. Javae 27 (1827), nom. cons.

***Gymnosiphon suaveolens* Urb., Simb. Antill. (Urbano). 3(3): 438 (1903).** (Figure 1I-L)

Type: —COLOMBIA. Guajira, Between Caracas and Santa Marta, *Karsen,* s.n (holotype: GOET000485 [digital image!]).

Mycoheterotrophic herb, erect, 7–37 cm tall. Rhizome short, covered by inconspicuous, narrowly ovate scales. Roots filiform, whitish, associated with mycorrhizae. Stem cylindrical, glabrous, generally unbranched, pink at the base becoming cream-white toward the apex, with well-defined internodes 3–4(–5) cm long and 0.3–0.4 cm in diameter. Leaves reduced, scale-like, sessile, adnate to the stem, ovate to lanceolate, 1.5–4 mm long and 1–2 mm wide, white becoming brown at maturity, apex obtuse to acute, arranged along the stem. Inflorescence terminal, in a raceme or in bifurcate cincinni, each cincinus 2.5–8 cm long, bearing 2–12 flowers; infructescence internodes 3–8 mm long. Bracts narrowly ovate, 1.5–5 mm long and 0.5–1.5 mm wide, apex obtuse to acute. Pedicels 1.3–6.7 mm long. Flowers white, erect or slightly inclined, 7–15 mm long; floral tube 5.5–9.8 mm long, white; outer tepals trilobed, 3.5–5.6 mm long and wide; central lobe depressed, ovate-triangular, 1.3–2.3 mm long and 2–3.3 mm wide; lateral lobes narrowly ovate-triangular, 1.2–2.1 mm long and 0.5–1.4 mm wide; inner tepals ovate, often inflated, 1–1.5 mm long and 0.5–1 mm wide. Androecium with connective bearing two deltate apical appendages, ca. 0.2 mm long and wide. Gynoecium with style 4–6.2 mm long, orange; stylar branches 0.3–0.4 mm long; stigmas 0.4–1.1 mm in diameter; appendages up to 5.5 mm long. Ovary obovoid, 2–4 × 1.1–2 mm. Fruit not observed.

Specimens examined: COLOMBIA. Quindío, **Génova:** vereda Río Gris Alto, Reserva Natural El Jardín, 2200 m, 26/IV/1997, *N. Rivera, et al.* 81 (HUQ!). **Pijao:** Vereda La María, Hacienda El Vetel, Carretera Pijao – El Broche, Margen derecha, 1870 m, 9/VI/1988, *G. Arbeláez S., et al.* 2573, (HUQ!; COL!). **Salento:** predio La Patasola, interior de bosque, sendero, 2407 m, 14/IV/2023, 4°41´25.221" N, 75°32'38.765" W, *A. Marulanda A.* 29 (HUQ!).

Gentianaceae Juss., Gen. Pl. [Jussieu] 141 (1789), nom. contras.

***Voyria flavescens* Griseb., Prodr. [A. P. de Candolle] 9: 85 (1845).** (Figure 1M-P)

Type: —BRASIL. Para:1977, *Poeppig* - 3064 (holotype. GOET006472 [digital image!]).

Mycoheterotrophic herb, erect, 3–15 cm tall. Roots filamentous, cylindrical, whitish to bluish-white, 5–10 cm long, associated with mycorrhizae. Stem cylindrical, terete, glabrous, generally simple or sparsely branched, 1–2 mm in diameter, white to whitish at the base, becoming pink to violet-purple toward the apex; internodes 0.2–1.5 cm long. Leaves reduced, scale-like, sessile, connate along the lower half of the stem, enclosing the main axis, triangular to narrowly triangular or ovate, 2–7 mm long and 1–2 mm wide, apex acute to acuminate, pale to yellowish; at the base of the stem often densely imbricate, forming a short sheath. Flowers solitary, occasionally two or three per individual, actinomorphic, pentamerous; pedicels 5–30 mm long, slender, glabrous. Calyx tubular to campanulate, bluish to purplish, 4–8(–12) mm long, with five conspicuous veins; lobes narrowly triangular, 3–4(–7) mm long and 1–1.5 mm wide, apex acute to acuminate. Corolla salverform, 14–30 mm long; tube whitish to cream at the base, gradually pinkish-purple toward the apex, 11–22 mm long; throat ca. 3 mm in diameter; limb with five triangular to narrowly triangular lobes, 3–10 mm long and 1–3 mm wide, violet-blue to lilac, apex acute to slightly caudate. Stamens five, inserted in the corolla tube, 3–10 mm below the throat; filaments 3–10 mm long; anthers subsessile, dorsifixed, ca. 1 mm long. Gynoecium included within the corolla; ovary ellipsoid to oblong-fusiform, 2–4 mm long, subsessile; style filiform, 10–19 mm long, slightly thickened at the base of the ovary; stigma bilobed to rotate, papillose. Fruit not observed.

Specimens examined: COLOMBIA. Quindío, Quimbaya: hacienda El Ocaso, bosque de guadua, 1140 m, 7/IV/ 2022, 4°35'25" N, 75°51'5" W, *A. Marulanda A.*, *C.A. Agudelo H.* 30 (HUQ!); hacienda El Ocaso, bosque de guadua, 1140 m, 3/VI/2023, 4°35'23.7"N, 75°51'03.6"W, *A. Marulanda A.*, *C.A. Agudelo H, S. Montoya R.* 43 (HUQ!).

Ericaceae Juss., Gen. Pl. [Jussieu] 159 (1789), nom. cons.

***Monotropa coccinea* Zucc., Flora 15(2, Beibl.): 100 (1832).** (Figure 1Q-T)

Mycoheterotrophic herb, erect, 10–30(–40) cm tall, reddish in coloration. Roots fleshy, short, densely branched, associated with mycorrhizae. Stem simple, cylindrical, fleshy, glabrous, reddish to wine-colored, whitish to pink at the base, decumbent during anthesis and becoming erect in fruit. Leaves reduced, scale-like, sessile, adnate to the stem, densely arranged along the axis, triangular to ovate-triangular, 4–12 mm long and 3–8 mm wide, apex acute to acuminate, margin entire, wine-colored to reddish-brown. Flowers solitary, terminal, and conspicuous, 2–3.5 cm long, initially decumbent, becoming erect during fruit development; pedicel 5–15 mm long. Calyx reduced, inconspicuous. Corolla campanulate to broadly urceolate, 20–35 mm long, fleshy, bright red to carmine red; petals 5, free or slightly connate at the base, oblong-ovate, 15–30 mm long, apex obtuse to rounded, inner surface glabrous. Stamens 10, arranged in two whorls, inserted at the base of the corolla; filaments short; anthers oblong, yellow to orange. Gynoecium with superior ovary, globose to subglobose, 5–8 mm in diameter; style 5–10 mm long; stigma discoid to capitate. Fruit a globose to subglobose capsule, 8–15 mm in diameter, dehiscent; seeds numerous, ellipsoidal, ca. 0.5 mm long.

Specimens examined: COLOMBIA, Quindío, Calarcá: viaducto Roblecitos, segunda calzada de La Línea, vía Cajamarca-Calarcá, 2000 m, 4°31'00,1"N, 75°36'27,3"W, 15/VII/2013, *N. D., Jiménez E. & J. Betancur* 1780, (HUQ!; COL!); predio Peñas Blancas, interior de bosque, bosque de robles, 2550 m, 4°28'40.8"N, 75°37'43.4"W, 17/II/2023, *A. Marulanda A.* 28 (HUQ!). **Génova:** camino finca Las Mirlas-Servia, 2400-2700 m, 14/II/2007, *M. C. Vélez* 1360, (COL!).

Achlorophyllous plants were documented in several municipalities of the department of Quindío. *Helosis cayennensis* had the highest number of documented municipal occurrences, with records from seven municipalities, followed by *Gymnosiphon suaveolens* and *Monotropa coccinea*. *Corynaea crassa* was documented in two municipalities, whereas *Voyria flavescens* was recorded in one municipality (Figure 2).

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Figure 1

Achlorophyllous plant species from the department of Quindío, Colombia

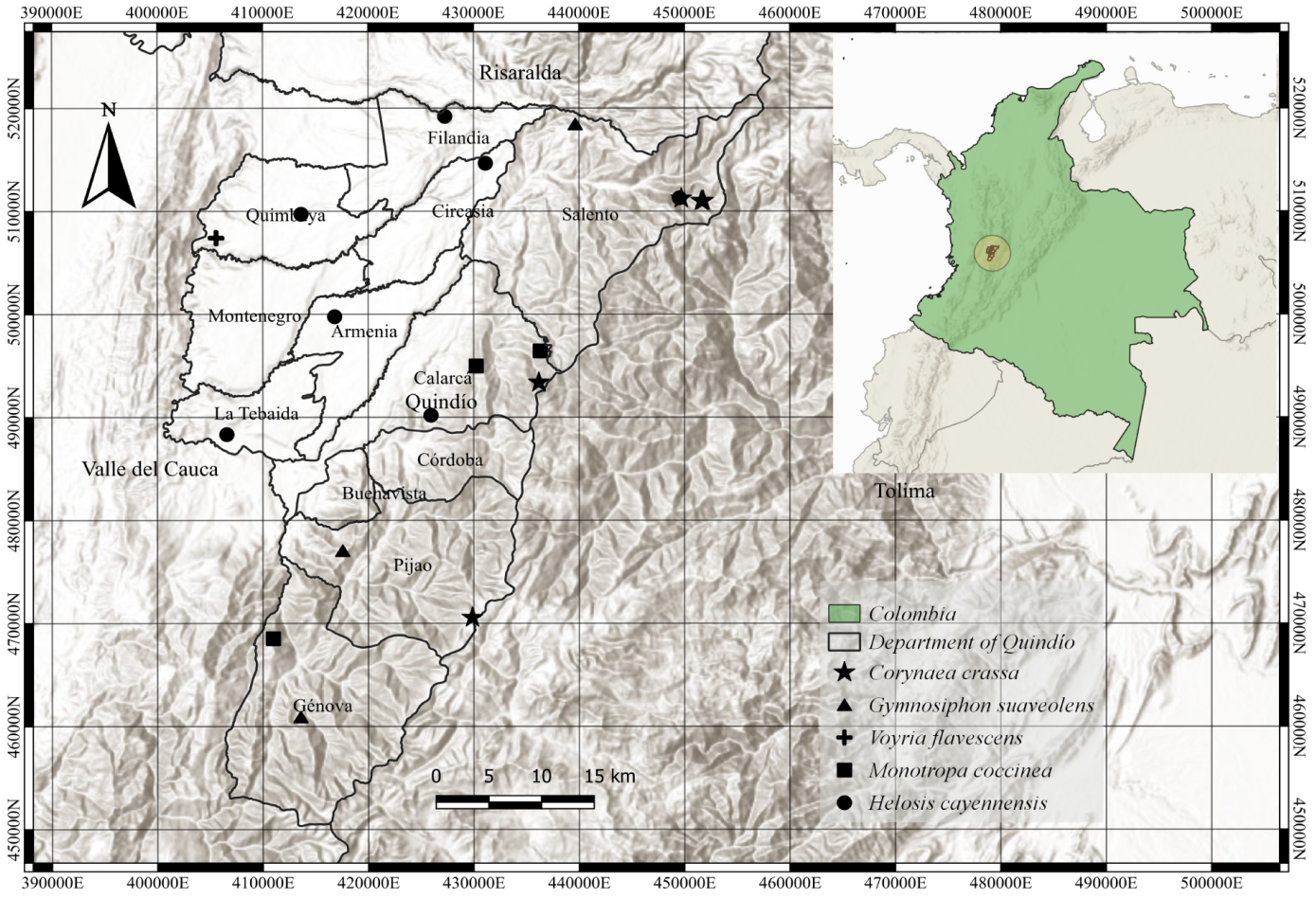


Note. Corynaea crassa (A-D). (A.) inflorescence, (B.) tuber, (C.) habit, (D.) herbarium specimen. *Helosis cayennensis* (E-H). (E.) inflorescence, (F.) rhizome, (G.) habit, (H.) herbarium specimen. *Gymnosiphon suaveolens* (I-L). (I.) flower, (J.) stem, (K.) habit, (L.) herbarium specimen. *Voyria flavescens* (M-P). (M.) flower, (N.) stem, (O.) habit, (P.) herbarium specimen. *Monotropa coccinea* (Q-T). (Q.) flower, (R.) stem, (S.) habit, (T.) herbarium specimen.

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Figure 2

Documented Occurrences of Achlorophyllous Species in the Department of Quindío, Colombia



Ecological observations

The documented occurrences of achlorophyllous species span different elevational ranges within the department of Quindío, including premontane, montane, high Andean forest, and Paramo environments (Figure 3).

The forests of the department of Quindío harbor a high diversity of plant species and particular climatic conditions which, collectively, provide optimal environments for the completion of life cycles of achlorophyllous species. Field observations indicate the presence of species such as *C. crassa*, associated with the roots of trees dominated by Asteraceae, Melastomataceae, Lauraceae, among others. Individuals of this species are commonly found at forest edges near long-lived trees or within the forest interior following tree fall after senescence. Such events often expose root systems and disturb the surrounding substrate, bringing to the surface both vegetative and reproductive structures of *C. crassa*. Its distribution occurs in high-elevation areas within high Andean Forests and Paramo ecosystems of the region, ranging from 2,800 to 3,800 m in elevation.

On the other hand, *H. cayennensis* is a very common species in lower elevations, ranging from 1,100 to 2,000 m, spanning premontane and montane forest life zones, and in some cases reaching high Andean forests up to 2,800 m. It is generally found along riverbanks and streams, growing in substrates composed of soil, sand, and rocks, and is frequently associated with vines and lianas. Its vegetative development occurs predominantly below the soil surface, which can make them difficult to detect during field sampling. These plants become evident when their reproductive structures emerge from the substrate, facilitating their detection and collection. During the flowering period, the species produces a peduncle 5–20 cm long and an inflorescence that may be coniform or, in some cases, rounded, emerging from the soil. This process commonly takes place between January and June.

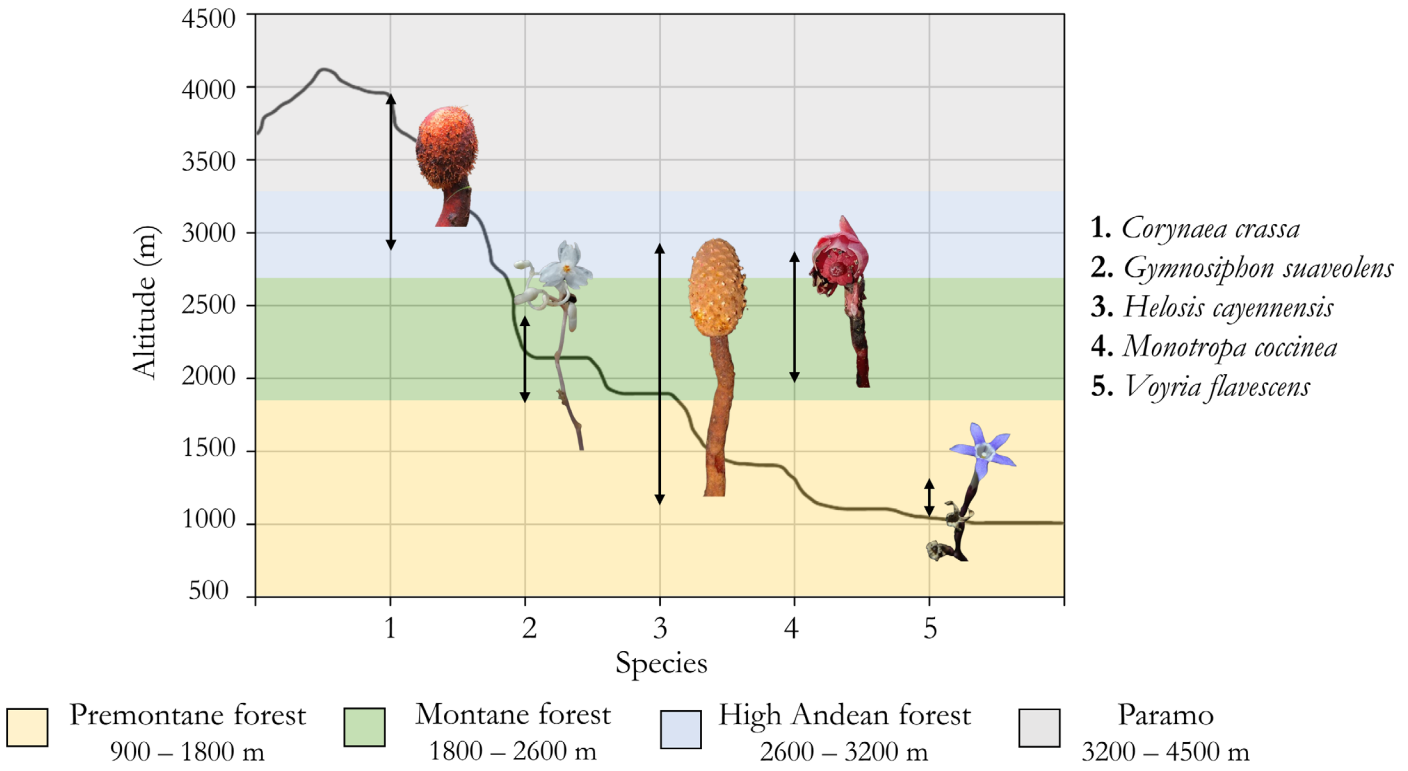
In addition to their altitudinal restriction, *C. crassa* can be readily distinguished from *H. cayennensis* when specimens are properly collected, extracting their complete vegetative structures from the substrate. In this way, it becomes evident that in *Corynaea* the stem forms a thickened, rough-surfaced tuber, whereas in *Helosis* it consists of a horizontal rhizome that extends underground, typically terete and smooth in appearance.

Gymnosiphon suaveolens is readily found in well-preserved forests or in those undergoing natural succession following human exclusion, typically within leaf litter and under the shade of trees and shrubs in montane forests and transitional zones toward high Andean Forests, generally between 1,800 and 2,500 m in elevation. Its white flowers emerge above the leaf litter between April and June. *Monotropa coccinea*, in contrast, differs from other mycoheterotrophic species in that it is exclusively associated with oak forests (*Quercus humboldtii*), where vegetation tends to be relatively homogeneous, with abundant leaf litter and decomposing logs. It is easily recognized by its reddish coloration, which contrasts with the brown surrounding substrate. It occurs primarily in montane forests from 2000 m, and in some cases in high Andean forests up to 2700 m in elevation. Its flowering period occurs mainly between February and July, and a marked association with fungi of the genus *Russula* Pers. was observed during field surveys. *Voyria flavescens* has thus far been recorded only in forest remnants dominated by *Guadua angustifolia* or in riparian forests, where arboreal vegetation is sparse and bamboo leaf litter is abundant. Its stem typically develops below ground, and flowering is commonly observed between April and June.

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Figure 3

Documented Elevational Ranges of Achlorophyllous Species in the Department of Quindío, Colombia



Discussion

The assemblage of non-photosynthetic plants documented for Quindío (four families, five species) constitutes a baseline for a group that is often underrepresented in regional inventories due to the short duration of its phenology, its cryptic habit, and its dependence on specific microenvironmental conditions (Krauczuk et al., 2013; Nickrent & Musselman, 2016). In this sense, the primary contribution of the present study lies in integrating field records and herbarium specimens to characterize not only species composition, but also distribution patterns across municipalities, altitudinal ranges, and habitat affinities.

Based on the Catálogo de Plantas y Líquenes de Colombia, the four families treated here (Balanophoraceae, Burmanniaceae, Gentianaceae, and Ericaceae) comprise a finite number of species at the national scale; considering only these four families, the species records from Quindío would represent approximately 13.16% of the total reported for the country (Bernal et al., 2016). Regarding holoparasitic plants, Quindío currently harbors 8.7% of the species reported for Colombia. Within the family Balanophoraceae, records from this territory represent 33.33% of the species reported at the national level (González & Pabón-Mora, 2023).

However, this percentage should not be interpreted as representative of the total heterotrophic/non-photosynthetic flora of Colombia, as additional families exhibiting holoparasitism or mycoheterotrophy occur in the country but are not included in the current departmental list (e.g., Thismiaceae, Triuridaceae, Cytinaceae/Lennoaceae, among others) (Bernal et al., 2016). Consequently, the most robust interpretation is that Quindío contributes a relevant fraction of the national diversity within the families effectively documented, although the departmental inventory will likely increase with targeted surveys.

In comparison with Antioquia, Colombia, a department with large-scale vascular plant inventories, a similar pattern is suggested, including families such as Balanophoraceae, Burmanniaceae, Gentianaceae, and Ericaceae, among others. Some of these families, however, include taxa for which no achlorophyllous representatives have been recorded in Quindío to date, such as Apodanthaceae, Convolvulaceae, Mitrastemonaceae, Orchidaceae, and Triuridaceae. Within the total reported for these families in Antioquia, Quindío comprises approximately 33.33% of the recorded species (Idárraga-Piedrahíta et al., 2011).

This contrast is informative, but it should be interpreted considering two main sources of variation: differences in sampling effort, and environmental heterogeneity along with the availability of microhabitats (e.g., riparian forests, bamboo stands, oak forests, montane and high Andean forests) (Krauczuk et al., 2013; Nickrent & Musselman, 2016). In particular, the ecological observations of the present study reveal marked restrictions in terms of habitat and elevation: *Helosis cayennensis* is frequently associated with riverbanks and alluvial substrates in lower montane zones; *Gymnosiphon suaveolens* is recorded within leaf litter in montane forests, including areas undergoing natural succession; *Monotropa coccinea* appears restricted to montane and high Andean oak forests (2,000–2,700 m), with evidence of fungal associations; and *Voyria flavescens* has thus far been found in forest remnants dominated by *Guadua* or in riparian forests with abundant bamboo leaf litter. Taken together, these patterns suggest that regional distribution is more strongly driven by host availability (in holoparasitic species) and by mycorrhizal networks in litter-rich habitats (in mycoheterotrophic species) than by the size of the department itself (Nickrent & Musselman, 2016).

Within the taxonomic component, the results support nomenclatural decisions of relevance for the region. In *Monotropa*, the historical assignment of Neotropical populations to *M. uniflora* has been questioned due to its predominantly Holarctic distribution. In agreement with previous treatments, the use of *M. coccinea* for the Neotropics is consistent with chorological and ecological differences, as well as with the fact that current taxonomic databases recognize *M. coccinea* as a distinct species and treat infraspecific combinations under *M. uniflora* as synonyms (Plants of the World Online [POWO], 2025). Additionally, the compiled native distribution in these sources (Mexico–Colombia) is congruent with the Andean records presented here (POWO, 2025).

In *Voyria*, the initial ambiguity due to morphological affinities with *V. pittieri* is understandable within the framework of classical monographs, a situation reflected in Quindío, where the examined specimens conform

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to the original description of *V. pittieri* (Maas & Ruyters, 1986). However, current taxonomic databases such as POWO recognize *V. pittieri* as a heterotypic synonym of *V. flavescens*. Therefore, adopting *V. flavescens* as the taxonomic concept in this study is a justified and reproducible decision (POWO, 2025; Tropicos.org, 2025).

Finally, in *Helosis cayennensis*, the infraspecific distinction between var. *cayennensis* and var. *mexicana* (based on the position of the scale belt on the peduncle) provides a useful framework. However, given that most examined specimens approximate the morphology of var. *mexicana* and diagnostic ambiguity persists, a conservative treatment at the species level within the departmental context is defensible, provided it is explicitly stated as a working hypothesis to be refined through morphometric evidence and, if possible, molecular data (Alvarado-Cárdenas & Vigosa-Mercado, 2016; Hansen, 1980; Hernández-Ledesma, 2018).

At the Neotropical scale, the composition and spatial patterns of holoparasitic and mycoheterotrophic plants recorded in the department of Quindío are consistent with trends widely documented for neighboring regions of Central and South America. Floristic literature consistently indicates that these groups are characterized by low species richness at the regional scale, coupled with high ecological specialization, strong dependence on specific hosts or mycorrhizal networks, and short phenological cycles factors that significantly contribute to their underrepresentation in conventional floristic inventories (Maas & Ruyters, 1986; Maas et al., 1986; Nickrent & Musselman, 2016).

In the South American context, studies focused on achlorophyllous plants from Argentina, Brazil, and the Guianas have revealed patterns comparable to those observed in Quindío, with representatives of Burmanniaceae and Gentianaceae largely confined to the understory of humid montane and submontane forests, in environments characterized by high leaf-litter accumulation and low anthropogenic disturbance (Krauczuk et al., 2013; Maas et al., 1986). Regarding holoparasitic plants, research conducted in the Andes of Ecuador and Peru indicates that Balanophoraceae, particularly the genera *Corynaea* and *Helosis*, exhibit broad altitudinal ranges, although they show a clear affinity for montane and high Andean forests and a strong dependence on the roots of woody species as hosts (Hansen, 1980, 2001). These observations are consistent with the altitudinal segregation recorded between *Corynaea crassa* and *Helosis cayennensis* in Quindío.

For Mesoamerica, taxonomic treatments of Balanophoraceae highlight the ecological breadth of *Helosis cayennensis*, documented from lowland humid forests to montane environments, which has led to infraspecific discussions based on regionally structured morphological variation (Alvarado-Cárdenas & Vigosa-Mercado, 2016; Hernández-Ledesma, 2018). Complementarily, floristic inventories conducted in El Salvador have recorded a relatively low number of mycoheterotrophic and root-parasitic plants belonging to Balanophoraceae, Burmanniaceae, Gentianaceae, Lennoaceae, and Orobanchaceae, whose distributions are fragmented and closely associated with humid and subhumid forests, as well as with specific edaphic conditions (Galán, 2019). The recurrent presence of genera such as *Helosis*, *Gymnosiphon*, and *Monotropa*, together with their affinity for shaded microhabitats and their low detectability in the field, suggests that the distribution of these non-photosynthetic plants is primarily determined by ecological and phenological constraints rather than by geographic extent *per se*. This pattern reinforces the validity of the regional comparisons established with the results obtained for Quindío.

In summary, the inventory presented here confirms that Quindío harbors a representative subset of non-photosynthetic plants within the families analyzed, and that their occurrence is strongly conditioned by specific microhabitats and, in the case of mycoheterotrophic species, by the associated fungal assemblages. As future research directions, it is recommended to standardize sampling across seasons (particularly targeting flowering peaks as suggested by field observations), expand surveys in riparian forests, bamboo stands (guaduales), and oak forests, and document host–parasite and fungus–plant associations through direct evidence (e.g., host identification in Balanophoraceae and characterization of associated fungi in mycoheterotrophic species) (Nickrent & Musselman, 2016).

Conclusion

This study provides relevant contributions to the knowledge of the composition and distribution of achlorophyllous plants in the department of Quindío. Despite the low number of recorded species, the results suggest high ecological specialization and a strong dependence on specific microhabitats and biotic interactions. The data obtained expand the regional understanding of this poorly documented group and highlight the importance of targeted sampling strategies. It is expected that these findings will serve as a basis for future ecological studies and for the development of conservation actions focused on these species and their associated habitats.

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Author Contributions

Conceptualization: AMA. Data curation: AMA, LÁR. Formal analysis: AMA, CAAH. Investigation: AMA, LÁR, CAAH. Methodology: AMA. Project administration: AMA. Resources: LÁR. Software: AMA. Supervision: AMA. Validation: LÁR, CAAH. Visualization: AMA. Writing – original draft: AMA. Writing – review & editing: AMA, LÁR, CAAH.

Conflict of Interest

The authors declare no conflicts of interest to report.

Data Availability Statement

The complete data analyzed during the current study can be accessed in the herbarium collection of the Universidad del Quindío (HUQ) and are presented in the body of the manuscript.

Ethical Compliance

Not applicable.

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