

## Three new species of *Myrosmodes* (Orchidaceae, Spiranthoideae) from Colombia and Ecuador

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**Abstract** Three new species of the Andean genus *Myrosmodes* are described: *Myrosmodes cleefi* Szlach., Mytnik and S. Nowak, *Myrosmodes reticulata* Szlach., Mytnik and S. Nowak, and *Myrosmodes subnivalis* Szlach., Mytnik and S. Nowak. The former two species are known from a single population each, from Columbia, and the latter from Columbia and Ecuador. Each species is described and illustrated, and detailed habitat and distribution data are provided. A distribution map of the new species and the distribution range of the genus is presented. A dichotomous key for determination of the Andean species and *Myrosmodes* is provided. Conservation status assessments are provided for each species; current International Union for Conservation of Nature (IUCN) red list categories and criteria are listed. A brief discussion of endemism in the Andes and Tropical Andes biodiversity hotspot is presented.

**Keywords** Taxonomy · New species · Orchidaceae · *Myrosmodes* · Colombia · Ecuador

The genus *Myrosmodes* Rchb.f. was described by Reichenbach (1854). Phylogenetic analyses conducted by Álvarez-Molina and Cameron (2009) revealed that *Myrosmodes* is a sister genus to *Aa* Rchb.f. and both are closely related to *Altensteinia* Kunth. These relationships were unresolved for many years, and the taxonomic status of these genera was unclear. Reichenbach filius (1878)

suggested that *Myrosmodes* and *Aa* are congeneric with *Altensteinia*. Schlechter (1912) distinguished *Aa* from *Altensteinia* again, but he decided to classify *Myrosmodes* as a synonym of *Aa*. Half a century later, some taxonomists (e.g., Schweinfurth 1958) considered *Altensteinia* as a good genus and recognized the other two as its synonyms. In Flora of Ecuador, Garay (1978) revalidated *Aa* and *Myrosmodes*, and these three genera are widely accepted up to date (Trujillo and Vargas 2011). All three genera are classified within the subtribe Prescottiinae Dressler (Dressler 1990, 1993; Szlachetko 1995). *Myrosmodes* is easily distinguishable from two other close relatives, *Aa* and *Altensteinia*, by possessing a short peduncle with scarious sheaths, a cucullate lip with fimbriolate margins, an accrescent peduncle anthesis, an inflorescence peduncle that is twice as long or more, flowers growing from the inflorescence apex to its base, and male flowers being distinctly smaller (Trujillo and Vargas 2011).

*Myrosmodes* includes 15 species, all of them occurring in South American Andes (Fig. 1). The species of *Myrosmodes* grow at the highest elevations at which an orchid has ever been reported, i.e., almost 5,000 m.a.s.l. (Trujillo and Vargas 2011). The habitats occupied by the *Myrosmodes* species are moist, freezing, and windy environments of the paramos and the arid conditions of the puna (Rundel 1994). The paramo occurs between the permanent snowline and the upper forest line, so in Andes being at about 3,200–5,000 m.a.s.l. (Josse et al. 2008). Plants of this type of vegetation are adapted to intense ultraviolet radiation, low atmospheric pressure, and drying effects of wind (Luteyn 1992). There are three main types of paramo recognized by physiognomy and structure of vegetation (Cuatrecasas 1968; Harling 1979; Cleef 1981; Ramsay 1992; Jørgensen and Ulloa 1994): the subparamo or shrub paramo, very often dominated by upright and prostrate

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**Fig. 1** Map of distribution of the new species on the distribution range of *Myrosmodes* (circle—*Myrosmodes subnivalis*, triangle—*M. reticulata*, square—*M. cleefi*; distribution range map from Pridgeon et al. 2003)



shrubs; the grass paramo with dominance of tussock grasses with stem rosettes and small patches of shrubs or monotypic, sometimes mixed forest (Ramsay and Oxley 1997; Cuesta and De Bievre 2008); and the superparamo, occurring on the slopes of the highest mountains in Ecuador and Colombia, being divided into two altitudinal belts, the lower and upper superparamo (Cuesta and De Bievre 2008). Puna constitutes some diverse ecosystems covering the high Central Andean Mountains from northern Peru to northern Argentina, above 3,400 m.a.s.l. (Halloy et al. 2008). This type of vegetation is dominated by grasses and shrubs, sometimes halophytic where covering salt plains (García and Beck 2006; Halloy et al. 2008). Some species of *Myrosmodes* are commonly seen among cushion-forming species of *Azorella* Lam. (Pridgeon et al. 2003). Anthelme et al. (2011) proved that the nurse plant *Azorella* may reduce stress reaction caused by harsh environments of the highest ecosystems of Andes.

Mittermeier et al. (2004) suggest that probably near to 10 % of the world's species of vascular plants occur in tropical Andes and the endemism of the region reaches up

to 50–60 % (or higher) of the species. Half of all known orchid species from tropical Andes were described in the last 20 years. Unfortunately, human impact is visibly seen in the decaying diversity of Andean ecosystems. Some regions have almost completely lost their original vegetation; however, some of them are still almost untouched. Paramos and puna are heavily impacted. They are greatly modified by agriculture, grazing, burning, or mining, and puna is also exploited by wood cutting, mostly for fuel. An additional threat is cutting of high Andean forest in Colombia for cultivation of opium puppy. As a result of human pressure in tropical Andes, perhaps only 25 % or less of natural vegetation remained (Mittermeier et al. 2004).

The representatives of *Myrosmodes* are small terrestrial plants with fleshy, fusiform, fasciculate, and often pubescent roots (Pridgeon et al. 2003). Leaves are small and coriaceous with thick cuticles. Inflorescence is lateral, many-flowered, basipetal, and andromonoecious (Berry and Calvo 1991). Peduncle is short and infundibuliform, accrescent after anthesis; sheaths are scarious. Flowers are

nonresupinate, white to greenish-white, subtended by scarious bracts. Sepals are subsimilar and dorsal sepal with petals adnate to the back of the gynostemium. Petals are much narrower than sepals. Lip is cucullate, tubular or flared, with fimbriate margins, often with moniliform hairs and obscure basal calli (Garay 1978; Vargas 1997; Pridgeon et al. 2003). Gynostemium is elongate, erect, rather slender, apically swollen, and dorsiventrally flattened. Conspicuous column part is longer than anther and reduced, rudimentary column foot obliquely adnate to ovary. Anther is erect, ovoid, dorsiventrally flattened, and immovable with two parallel chambers. Pollinia are two, but bipartite, powdery, and oblong-ovoid. Caudiculae are absent. Very large and conspicuous staminodes are wing-like, rather thin. In basal part they are fused with filament and stigma margins, apically being free, almost entirely enclosing anther and crossing each other at apex over anther. Ventral, 3-lobed, confluent, large, transversely elliptic, and flat stigma is surrounded by thick and fleshy collar-like structure. Rostellum is inconspicuous, truncate, and limited to apical portion of stigma median lobe. Single viscidium is relatively small, detachable, cellular, and multilayered (Szlachetko and Rutkowski 2000).

#### Key to the North Andean species of *Myrosmodes*:

1. Lip subquadrate in outline, middle lobe erect, stiff, oblong, truncate, lip venation strongly thickened, forming a very characteristic net ..... *M. reticulata*
- 1\*. Lip not as above ..... 2
2. Ovary long-rostrate at apex, lip distinctly clawed, lamina cordate ..... 3
- 2\*. Ovary not rostrate, lip cuneate-flabellate ..... 6
3. Rostellum 3-lobed, lip obscurely 3-lobed, middle lobe terminal ..... *M. rostratum*
- 3\*. Rostellum truncate, lip entire, orbicular in outline ..... 4
4. Sepals and petals entire ..... *M. rhynchocarpum*
- 4\*. Sepals and petals erose toward apex ..... 5
5. Petals acute, irregularly dentate near apex, lip papillose inside ..... *M. breve*
- 5\*. Petals obtuse, minutely erose-denticulate near apex, lip glabrous inside ..... *M. cochleare*
6. Sepals dorsally mucronate at erose apex, petals erose-denticulate near apex, lip papillose in center: *M. ustulatum*
- 6\*. Sepals dorsally glabrous at apex, petals unevenly lacerate-serrate near apex, lip glabrous in center ..... 7
7. Sepals and petals equal in length, anther on free filament ..... *M. filamentosum*

- 7\*. Dorsal sepal and petals shorter than lateral sepals, anther's filament fused with clinandrium ..... 8
8. Lip widest at base, cordate in outline, margins of lateral sepals entire ..... *M. nubigenum*
- 8\*. Lip widest in the middle, lip obtusate, margins of lateral sepals erose ..... 9
9. Lip with fleshy pads in sinus between the middle and lateral lobes, lateral lobes thickened ..... *M. cleefi*
- 9\*. Lip without fleshy pads in sinus between the middle and lateral lobes, lateral lobes thin ..... *M. subnivalis*

The studies of pollination of *Myrosmodes cochleare* Garay conducted by Berry and Calvo (1991) revealed that the species is not pollinated by bumblebees, a frequent pollinator of flowering plants in high mountain range areas, but by calliphorid flies and wasps.

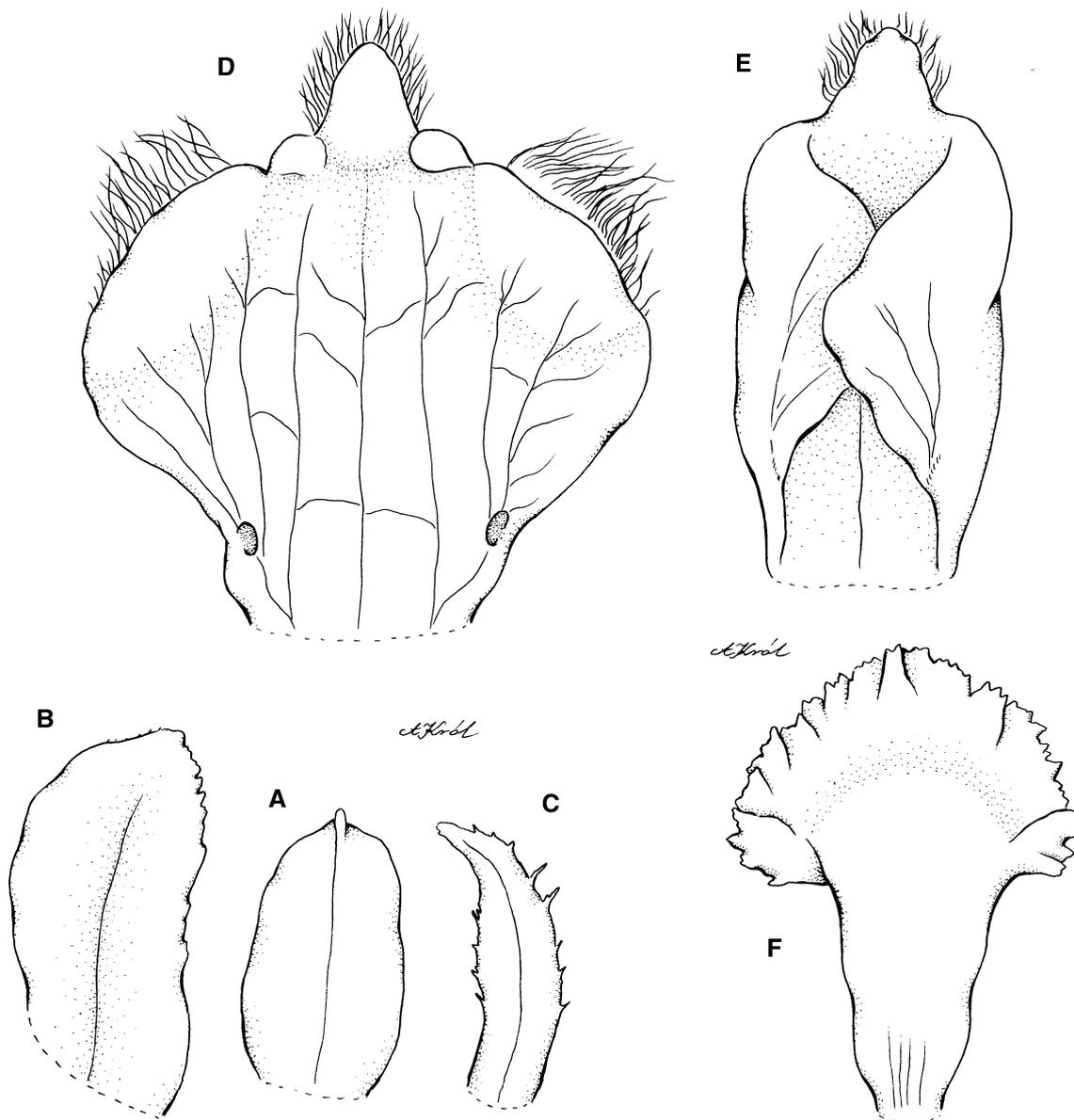
The genus *Myrosmodes*, as well as other closely related genera of Prescottiinae, have been the subject of ongoing taxonomic work by our team for years. We study herbarium specimens and explore the South American highlands. The collected specimens are determined based on comparison with type material and original descriptions. The taxonomic study on the Colombian collection of orchid specimens deposited in the Herbarium of Universidad Nacional de Colombia in 2012 revealed some new species of *Myrosmodes*, and therefore, we present them below.

#### *Myrosmodes cleefi* Szlach., Mytnik and S. Nowak sp. nov. (Fig. 2)

The species is related to *Myrosmodes nubigenum* Rchb.f., but the lip is two times larger, widest in the middle, obtusate in outline, lateral sepals cochleate with erose margins, dorsal sepal oblong-elliptic with keeled apex.

Type: Cleef A.M. 1298-Colombia, Meta, Paramo de Sumapaz, Cerro Nevado del Sumapaz, superparamo, Pico del Nevado, cocas calichosas, flores verdosas, asociado con musgos, alt. 4,300 m (30 Jan 1972), (COL! 180092 holotype).

Terrestrial plants to 7 cm tall, erect, concealed by scarious bracts. Leaves gathered in the basal rosette, several per stem, petiolate; petiole to 1.5 cm long; blade to 2.5 × 1.2 cm, ovate to ovate-lanceolate, subobtusate. Inflorescence 4 cm long, very dense, conical, many-flowered. Flowers green. Floral bracts 15 mm long, flabellate from the cuneate lower part, margins undulate, erose, and undulate. Ovary 8 mm long, glabrous. Sepaline tube 3 mm long. Dorsal sepal 5 × 3 mm, oblong-elliptic, concave, 1-nerved, keeled outside at the apex. Petals 4.8 × 1.3 mm, lanceolate, falcate, acuminate, 1-nerved, with several, irregular fimbriae along margins. Lateral sepals 8–9 × 4.5 mm, obliquely oblong-elliptic, obtuse, concave, erose on margins. Lip 9–10 mm



**Fig. 2** *Myrosmodes cleefi* Szlach., Mytnik and S. Nowak: **a** dorsal sepal, **b** lateral sepal, **c** petal, **d**, **e** lip, **f** bract [Cleef 1298 (COL); drawn by A. Król]

long in total, apically 3-lobed, obrullate in outline, widest near the middle, with two small, globose, mamilliform thickenings at the base, nerves 7, branching; the middle lobe  $1.8 \times 1.6$  mm, oblong-ovate, obtuse, thick, fimbriate on margins; the lateral lobes much thickened, fimbriate on margins, crossing each other in natural position; sinus between lobes with thick, fleshy pads.

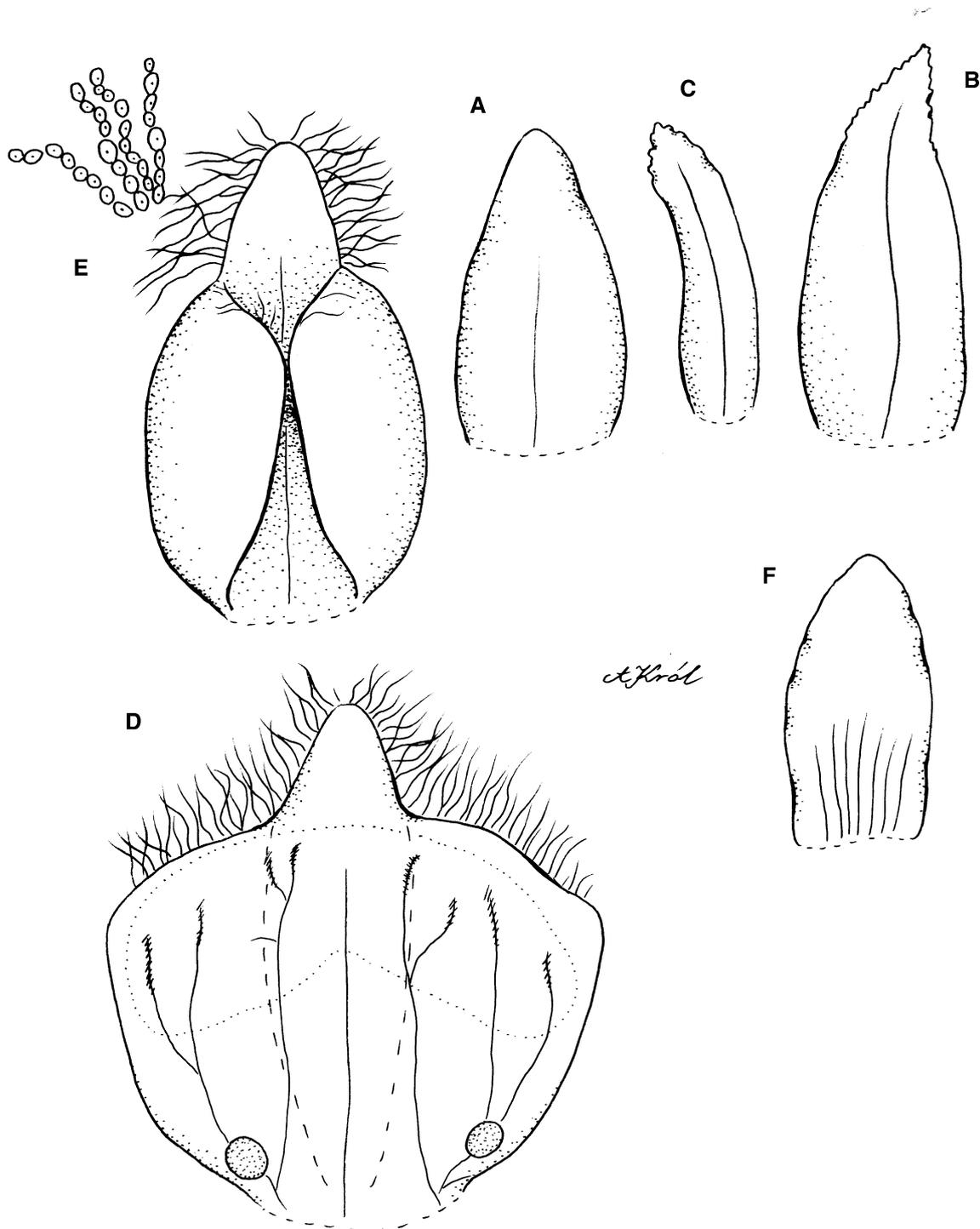
Ecology: terrestrial in superparamo, among mosses; altitude: 4,300 m; distribution: known from one population from Paramo de Sumapaz in the Department of Meta, Colombia; conservation status: CR B2ab (ii, iii) AOO = 4 km<sup>2</sup>; etymology: dedicated to A. M. Cleef, who collected the type specimen.

***Myrosmodes subnivalis* Szlach., Mytnik and S. Nowak sp. nov. (Fig. 3)**

This species is allied to *Myrosmodes nubigenum* Rchb.f., but the lip is thin, obrullate in outline, without fleshy pads in sinus between the middle and lateral lobes, the lateral lip lobes thin and delicate.

Type: J. Aguirre C. and A.M. Cleef 889-Colombia, Santander, Paramo del Almorzadero, desde el paramo bajo hasta superparamo, alt. 3,900 m (17–19 Nov 1978), (COL! 411155 holotype).

Plant to 4.5 cm tall, enclothed in numerous, scarios, semitransparent bracts. Leaves 5–6, gathered in the basal



**Fig. 3** *Myrosmodes subnivalis* Szlach., Mytnik and S. Nowak: **a** dorsal sepal, **b** lateral sepal, **c** petal, **d**, **e** lip, **f** bract [J. Aguirre C. and Cleef 889 (COL); drawn by A. Król]

rosette, petiolate; petiole 0.5 cm long; blade  $2.5 \times 0.8$  cm, lanceolate to oblong-lanceolate, subobtuse to subacute. Inflorescence 2 cm long, densely many-flowered. Flowers small. Floral bracts 11 mm long, ligulate-ovate, rounded at apex, semitransparent. Ovary 6 mm long. Sepaline tube to 3 mm long. Dorsal sepal  $3 \times 1.2$  mm, oblong-ovate,

rounded at apex, 1-nerved. Petals  $3 \times 0.5$  mm, linear to linear-lanceolate, falcate, acute, apical margin erose, 1-nerved. Lateral sepals  $4.5 \times 1.7$  mm, lanceolate-ovate, somewhat sigmoid, acute, apical margin erose. Lip 4.5 mm long and wide, obrullate in outline, thin, with 3 branching nerves, slightly thickened apically, ciliate along midnerve,

with 2 subglobose, mamilliform thickenings at the base, apical half densely covered by long hairs resembling strings of beads, 3-lobed; the middle lobe  $1.4 \times 1$  mm, oblong-ovate, obtuse; lateral lobes thin; no fleshy pads in sinus between lobes.

Ecology: terrestrial in paramo and superparamo, on wet rocks between lateral moraines, between glacier; altitude: 3,720–4,500 m; distribution: known from Ecuador and Colombia; conservation status: EN B2ab(ii, iii) AOO =  $16 \text{ km}^2$ ; etymology: collected at the highest elevation at which a Neotropical orchid has ever been reported (4,500 m.a.s.l.).

Representative specimens: Barclay and P. Juajibioy 7426-Colombia, Boyaca, Cordillera Oriental, Sierra Nevada del Cocuy, Alto Ritacuva, on high, wet rocks between lateral moraines, between tongue of glacier, alt. 4,500 m (11–29 Apr 1959), (COL!); S. Diaz P., H. Valencia Z. and R. Jaramillo M. 1759-Colombia, Risaralda, Mpio, de Pereira, Alrededores de la Laguna Otun, terrestre sobre cojines de *Plantago rigida*, alt. 4,000–4,300 m (3 Feb 1980), (COL!).

Other materials examined: Barclay and P. Juajibioy 9084-Ecuador, Napo-Pastaza, alrededores de La Cordillera de Los Llanganates, Chuchila Sacha o Ainchilibi, between grass clumps, lower slopes of Ainchilibi above cienga (Chihuila Sacha), alt. 3,720 m (25–29 Aug 1959), (COL!).

***Myrosmodes reticulata* Szlach., Mytnik and S. Nowak sp. nov. (Fig. 4)**

This species is related to *Myrosmodes nubigenum* Rchb.f., but the lip is subquadrate in outline, with stiff, oblong, truncate middle lip lobe. Venation of the lip is strongly thickened, forming a very characteristic net.

Type: R. Jaramillo M., van der Hammen, A.M. Cleef and O. Rangel 5655-Colombia, Risaralda, Cordillera Central, Mpio, de Pereira, Parquet de los Navados, Nevado de Santa Isabel, vertiente WNW, superparamo bajo, morrena reciente, alt. 4,400–4,450 m (17 Jan 1980), (COL! 218517 holotype).

Plants to 10 cm tall, erect, encloded by scarious, semitransparent bracts. Leaves 4–7, gathered in the basal rosette, petiolate; petiole 1–1.5 cm long; blade to  $1.5 \times 1.2$  cm, ovate to broadly ovate, obtuse to subobtuse. Inflorescence 3 cm long, densely many-flowered. Flowers small. Floral bracts to 22 mm long, semitransparent, scarious. Ovary 3.5 mm long. Sepaline tube 1 mm long. Dorsal sepal  $3.5 \times 2.8$  mm, ovate-triangular, subobtuse, concave, thin. Petals  $3.5 \times 0.8$  mm, linear-lanceolate, obtuse to subobtuse, sigmoid, with some hairs on margins, 1-nerved. Lateral sepals  $3.6 \times 3$  mm wide, obliquely oblong-ovate to elliptic, obtuse, concave, thin. Lip 4.2 mm long in total,

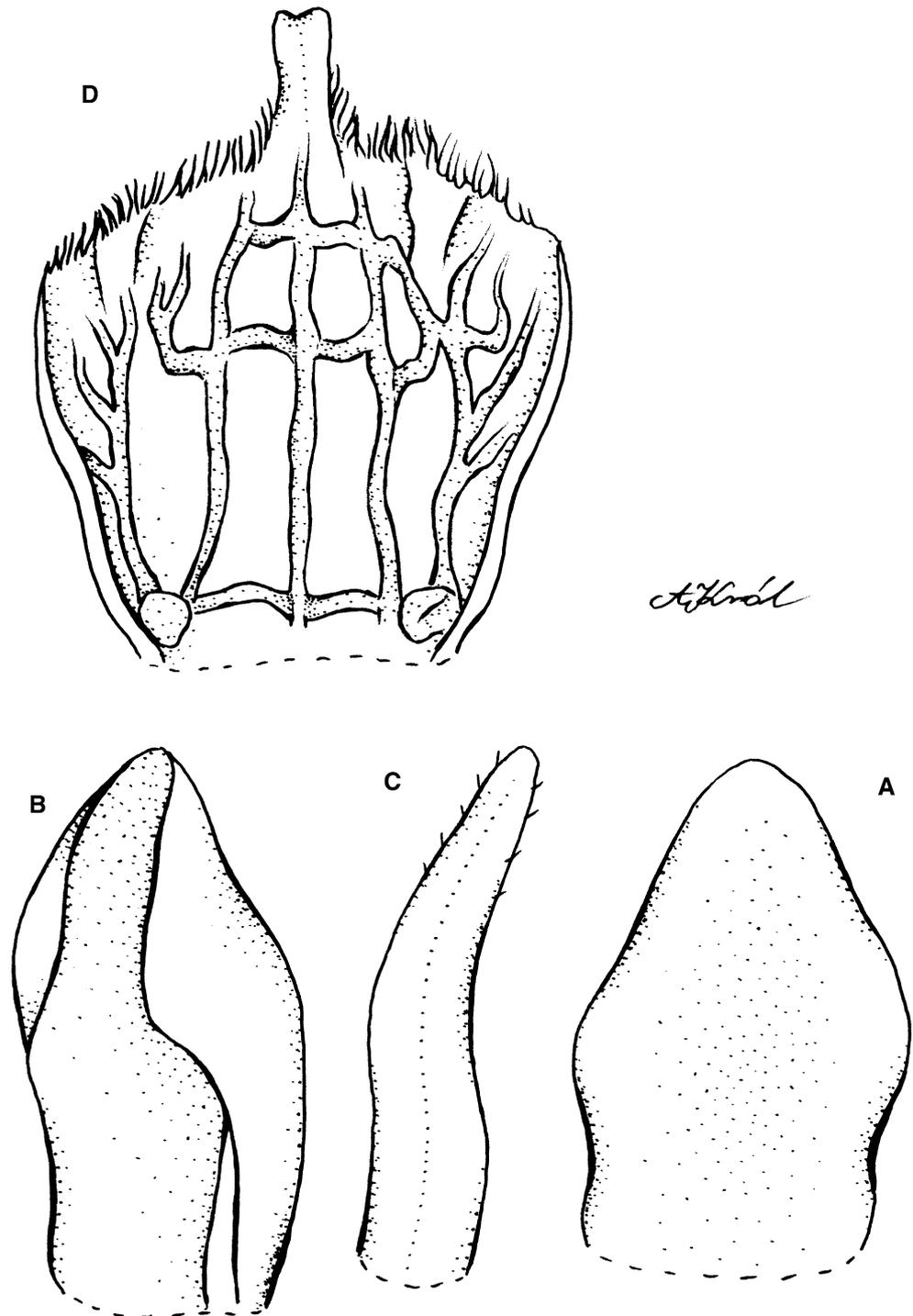
concave, thin, subquadrate in outline, nerves branching and anastomosing, forming a prominent net, 3-lobed at apex; the middle lobe 1.2 mm long, stiff, oblong, truncate at apex; basal part  $3 \times 4$  mm, truncate at apex, pubescent on apical margin and somewhat undulate. Gynostemium 3 mm long.

Ecology: terrestrial in superparamo; altitude: 4,400–4,450 m; distribution: known so far from one population from the Department of Risaralda, Colombia; conservation status: CR B2ab(ii, iii) AOO =  $4 \text{ km}^2$ ; etymology: in reference to very characteristic nervation net of the lip.

*Myrosmodes* has weak representation in herbarium specimens, so it can be assumed that this genus is rare in the environment. Additionally, orchids have specific biology, such as symbiosis with fungus needed for germination of seeds or tight adaption to pollinators; in some cases, self-pollination is possible, especially in harsh ecosystems such as paramo and puna, but this is unprofitable in terms of population genetic condition. Furthermore, human impacts have drastically increased over the last 20 years in both paramo and puna (Gondard 1988; De Koning and Veldkamp 1998). Activities such as cattle grazing and introduction of exotic species, often in cultivation and others related with human inhabitation, have had important and negative influence on vegetation composition and structure, ratio of ground biomass, hydrological behavior of the system, and chemical and physical properties of the soils (Hofstede et al. 1995; Ramsay and Oxley 1997; Poulenard et al. 2001, 2004; Farley et al. 2004; Cuesta and De Bievre 2008). Paramo is highly fragmented, which can be a barrier to propagation for plants living in this formation, and thus also for species of *Myrosmodes*. Additionally, only 43.4 % of all paramo in Andes is formally protected (Cuesta and De Bievre 2008). In our opinion, all these factors provide strong support for the conservation status proposed for the new species described herein (IUCN 2010).

The new species described here are restricted in distribution to the Andes in Colombia and Ecuador, part of the Tropical Andes biodiversity hotspot (Mittermeier et al. 2004). The Tropical Andes hotspot contains the richest and most diverse flora on Earth (Mittermeier et al. 2004). In addition, many Andean areas, such as parts of the Department of Meta in Colombia or Cordillera de Los Llanganates in Ecuador, are unexplored and their species diversity is still poorly known (Davis et al. 1997). The newly described species are known from four protected areas of IUCN category II: in Colombia from Sumapaz National Park (*Myrosmodes cleefi*), Los Nevados Natural National Park (*M. reticulata* and *M. subnivalis*), and Sierra Nevada del Cocuy Chita o Guican Natural National Park (*M. subnivalis*), and in Ecuador from environs of Llanganates National Park (*M. subnivalis*). These areas embrace largely paramo formation, with Sierra Nevada del Cocuy

**Fig. 4** *Myrosmodes reticulata* Szlach., Mytnik and S. Nowak: **a** dorsal sepal, **b** lateral sepal, **c** petal, **d** lip [R. Jaramillo M., van der Hammen, Cleef and O. Rangel 5655 (COL); drawn by A. Król]



representing the highest diversity and proportion of endemism in the paramos of the East Cordillera. In the superparamo of this region there are about 20 endemic species, while in the superparamo of Sumapaz there are only 3 endemic species. The main threats to the paramo in these locations are intensive sheep and cattle grazing, occasionally with burning, wood cutting, and mining development (Davis et al. 1997).

The three new species are endemic to tropical Andes in Colombia and Ecuador; furthermore, *Myrosmodes cleefi* and *M. reticulata* are known from single localities in Colombia. They occur in paramos, which are heavily impacted. Based on these facts, in our opinion *M. cleefi* and *M. reticulata* lie in the critically endangered IUCN category (CR B2ab) whereas *M. subnivalis* should be considered an endangered taxon (EN B2ab).

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