Lycopodiaceae in Brazil. Conspectus of the family III. The genera *Huperzia* and *Phlegmariurus*

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**Abstract**
The subfamily Huperzioideae of the Lycopodiaceae includes 41 species in Brazil. The genus *Huperzia* is represented by a single species, and *Phlegmariurus* has 40 species. They occur in most habitat types with a humid climate, from tropical lowland forest, to montane forest, and campo vegetation in the highlands. There are 25 endemics, more than half of the species. The present treatment includes nomenclature, descriptions and illustrations of all species, and a key for their identification. Reference collections are cited and summarize the distribution of the species and document their identity. Short discussions deal with problems of species delimitation and compare closely related species.

**Key words:** diversity, floristics, lycophytes, phytogeography, taxonomy.

**Introduction**
This is the third and final part of a series of treatments of the Brazilian Lycopodiaceae. It deals with the genera *Huperzia* Bernh. and *Phlegmariurus* Holub, including a total of 41 species. The first part (Øllgaard & Windisch 2014) treated the genera *Austrolycopodium* Holub, *Diphasiastrum* Holub, *Diphasium* C.Presl ex Rothm., and *Lycopodium* L. (subfamily Lycopodiioideae according to Wagner & Beitel 1992), including 5 species, and gave a general introduction to the family, the history of its study and exploration in Brazil, and keys to the genera of the family. The second part (Øllgaard & Windisch 2016) treated the genera *Lycopodiella* Holub, *Palhinhaea* Carv. Vasc. & Franco and *Pseudolycopodiella* Holub (subfamily Lycopodielloideae of Wagner & Beitel ex Øllgaard 2014), including 17 species. The present part deals with the subfamily Huperzioideae of Wagner & Beitel (1992) validated by Øllgaard (2014), by far the largest species group in Brazil.

Nessel (1927, 1955) included several extralimital species. They are listed and excluded in Øllgaard & Windisch (1987) and are not further treated here.

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Material and Methods

The methodology used in this study is the same adopted by the first and second part of this treatment (Øllgaard & Windisch 2014, 2016). A list of studied collections is included in the descriptions of each species, but in cases of great numbers of collections only a number of reference collections are mentioned to indicate the general distribution. Where only reference collections are given, complete listings are available from the first author.

The cited specimens serve both for identification purposes, and to document general distribution. However, several collections assigned to Glaziou apparently are far out of the range of the species in question, and may serve only for identification.

Where useful published illustrations are available they are cited.

Results

Taxonomic treatment

These two genera can be distinguished from the remaining genera of the Lycopodiaceae in Brazil by the characters presented in the following key:

Key to the Brazilian genera of the Huperzioideae

1. Stems isotomously branched throughout, without elongate, indeterminate main stems, but sometimes heteroblastic, roots usually forming one basal tuft, sporophylls and vegetative leaves alike, or the sporophylls, if smaller, persisting and green, not subpeltate and ephemeral; spores foveolate-fossulate (Huperzioideae).
   2. Plants terrestrial, usually with gemmiferous (=bulbiferous) lateral branchlets, spores concave between laesurae, with truncated corners and foveolate proximal faces; plants terrestrial, ascending to erect.................................................................
   2’. Plants terrestrial or epiphytic, lacking gemmiferous branchlets, spores plane between laesurae, with evenly angular corners, proximal surfaces usually plain; plants terrestrial or epiphytic, erect or pendulous........................................................................................................................................

1’. Stems anisotomously branched throughout, not gemmiferous, the branches differentiated into elongate, indeterminate, rhizomatous, or creeping, trailing, or climbing main stems, and usually determinate branchlet systems; sporophylls strongly modified, ephemeral, unlike vegetative leaves, peltate or subpeltate, aggregated in compact, terminal strobili.................... (Lycopodioidae: Austrolycopodium, Diphasiastrum, Diphasium, and Lycopodium s. str.) and (Lycopodielloideae: Lycopodiella s. str., Palhinhaea, and Pseudolycopodiella) (Øllgaard & Windisch 2014, 2016).


Terrestrial, erect or ascending, homophyllous or irregularly seasonally heterophyllous, gemmiferous plants; spores triangular with truncate corners and concave sides between laesura.

Temperate, arctic and alpine regions of the Northern Hemisphere, montane and alpine regions in the Paleotropics, scattered in temperate regions of the southern hemisphere. Huperzia Bernh. (mainly Southeast Asia) has few Neotropical records (Mexico, Greater Antilles, Southern Brazil). Speciation in the group seems associated with a high frequency of hybridization (Beitel 1979,1984; Wagner et al. 1985).

The formation of gemmae is restricted to this group. The gemmae are interpreted as easily detachable shoot tips of highly anisotomous branchlets, and thus represent a specialized feature in the Lycopodiaceae. Their structure was described by Stevenson (1976), who also reviewed...
the earlier gemma studies. Gemma formation is associated with a distinct spore type (the Selago type of Wilce 1972), in which the spores are distinctly triangular with truncate corners in polar view and have more or less concave, usually deeply pitted proximal faces. This is in contrast to the suborbicular polar view, with evenly rounded or angular corners, and flat, almost smooth proximal faces in Phlegmariurus Holub. The two spore types are easily distinguished in the light microscope (Øllgaard & Windisch 2014).

**Huperzia catharinae** (Christ) Holub, Folia Geobot. Phytotax. 20: 71. 1985. Fig. 1a-d


**Figure 1** – a-d. *Huperzia catharinae* – a. growth habit; b. vegetative leaf; c. distal division with sporangiate leaves and gemmiphores; d. gemmiphore. (Brazil: Santa Catarina, bords de la Serra do Oratorio, *Ule 2313* (HBG)).
Plants terrestrial, ascending to erect from a decumbent base, to ca. 15 cm tall or to 20 cm long, sparsely branched, to 4 times dichotomous. Shoots unequally thick, with repeated constrictions along stems due to periodic variation in leaf length and gemmophore development, 10–27 mm in diam. Stems excl. leaves produced zones, incl. leaves, sporangiate in separate, seasonally gemmiphore development, 10–27 mm in diam. of heterophyllous species associated or not with presence of sporangia. Sporophylls and vegetative leaves alike or sporophylls shorter, not peltate, persisting and green after sporangium dehiscence. Sporangia axillary, reniform, isovalvate, with a short slender stalk; side and inner walls of sporangium epidermis cells sinuate, thickened and lignified. Spores foveolate or fossulate. Gametophytes usually subterranean or deep in epiphytic substrate, mycorrhizal, cylindrical with radial or bilateral symmetry, with pluricellular, uniseriate hairs among the gametangia.

Distribution: Perhaps 300 species worldwide, 40 in Brazil of which 24 are endemic.

Phlegmariurus Holub is pantropical and with few temperate species. Species diversity is highest throughout the tropics in evergreen montane forests, and in the wet Andean grass and shrublands in South America.

The genus Phlegmariurus Holub until fairly recently was generally included in the genus Huperzia Bernh.. However, Phlegmariurus Holub is distinct from Huperzia Bernh. with regard to spore type and the lack of gemmae. The species of Huperzia Bernh. are entirely terrestrial whereas the majority of Phlegmariurus Holub species are epiphytic. There are no known intergeneric hybrids. Whereas Huperzia Bernh. appears to be entirely terrestrial, the terrestrial species in Phlegmariurus Holub have been derived from epiphytic elements in the genus according to Wikström et al. (1999). There is phylogenetic evidence supporting the two genera as separate lineages, e.g., Field et al. (2016).

In Phlegmariurus Holub the sporangia are situated in the axils of sporophylls that may be similar to the vegetative leaves, or reduced in size and occupy major parts of constricted distal divisions in pendulous epiphytes. These are commonly referred to as strobili, but we prefer to restrict the term strobilus to the homologous structures in Lycopodioidae and Lycopodielloideae. In these subfamilies, the sporophylls occupy the strobili entirely, are ephemeral, and wither during or just after spore release. In contrast, in Phlegmariurus Holub, the sporophylls commonly occupy only part of the constricted divisions, and zones with sporophylls may alternate seasonally with vegetative leaves of the same aspect, and the sporophylls remain green indefinitely after spore release. We prefer the term sporangiate division or sporangiate branch for these structures.
**Key to the species of *Phlegmariurus* Holub in Brazil**

1. Plants erect, or ascending to erect, terrestrial or epiphytic; shoot apices erect. Leaf margins entire, denticulate or ciliolate.

2. Plants heteroblastic, with creeping and often rooting horizontal to prostrate-ascending, basal, rejuvenating shoots, these producing erect, simple or sparsely branched aerial branches (Fig. 4a)

   2’. Plants homoblastic, shoots not differentiated into creeping horizontal and erect aerial shoots.

3. Leaf margins denticulate (at least of some leaves, sometimes minutely and remotely denticulate) by pointed teeth, or ciliolate.

   4. Leaves distinctly convex abaxially, at least in the upper divisions.

   5. Leaf margins entire, denticulate or ciliolate.

   5’. Leaves 3–5 × ca. 1 mm (Fig. 7c,d) .......................... *Phlegmariurus rostrifolius*

   4’. Leaves abaxially flat or concave sometimes with a prominent vein.

   6. Leaves 8–11 × 1.5–2 mm, linear-lanceolate, usually 8–10-seriate (Fig. 11a,b) ....

      6’. Leaves 4–8 × 0.5–1 mm, linear-subulate or linear-lanceolate, usually 10–14-seriate (Fig. 20a-d).

3’. Leaf margins smooth, not denticulate or ciliolate.

7. Leaves ascending to appressed.

8. Leaves distinctly convex abaxially, at least in distal divisions.

9. Leaves of upper divisions sharply carinate, plants not red (Fig. 4d-f)...........

    9’. Upper divisions with leaves rounded to somewhat conduplicate abaxially, plants green or red.

10. Plants green, leaves in whorls of 6–8 (Fig. 7a,b) .................................

10’. Plants distinctly red, leaves in whorls of 4–5 (Fig. 18c-e) ......................

8’. Leaves distinctly flattened abaxially, or flattened with prominent vein.

11. Leaves in whorls of 8–10, 16–20-seriate (Fig. 22a-c)..............................

11’. Leaves in whorls of 6–7, 12–14-seriate (Fig. 22d,e) ..............................

7’. Leaves patent or recurved.

12. Leaves filiform to narrowly linear, 1 mm or less wide.

13. Longest leaves 6 mm long or shorter.

14. Basal half of leaf ascending, from there strongly recurved and hook-like, branching angles divaricate (Fig. 16a,b) .... *Phlegmariurus intermedius*

14’. Leaves recurved from a patent base, branching angles narrow (Fig. 10a-c)..............................

15. Leaves linear to filiform, canaliculate and involute, or bisulcate.

16. Leaves bisulcate above, with prominently tumid margins and vein, leaf bases with widening, prominently decurrent margins and median vein, usually bright red (Fig. 14c,d)..............................

   16’. Leaves canaliculate to involute, often with prominent vein abaxially near the base, decurrent leaf base usually not wider than the lamina base (Fig. 14e,f)..............................

15’. Leaves linear, flat or with slightly revolute margins

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17. Plants usually epiphytic, leaf lamina usually twisted at the base to a vertical position (Fig. 6a,b) .......................................................... \textit{Phlegmariurus dichotomus}

17'. Plants terrestrial or rupestral, leaf lamina not twisted, leaves patent to reflexed.

18. Leaves 6–13 × 0.6–0.8 mm, stems 1.3–2 mm thick at the base (dried) (Fig. 10d,e) ...... .......................................................... \textit{Phlegmariurus nudus}

18'. Leaves 11–19 × 0.8–1.3 mm, stems 2.5–4 mm thick at the base (dried) (Fig. 14a,b) .... .......................................................... \textit{Phlegmariurus hippurideus}

12'. Leaves narrowly to broadly lanceolate, more than 1 mm wide.

19. Leaves subdecussate, rupestral or epiphytic plants, scrambling, usually densely branched and divaricate, usually with red stems (Fig. 5d-f) ......................... \textit{Phlegmariurus erythrocaulos}

19'. Leaves borne in whorls of (3–)4–10.

20. Longest leaves less than 7 mm long, strongly recurved, rigid and hook-like, 16–20-seriate (Fig. 18a,b) .......................................................... \textit{Phlegmariurus mooreanus}

20'. Longest leaves 8–20 mm long, straight to recurved, (6–)8–16 seriate.

21. Leaves usually 5–9 mm long, 1–1.3 mm wide, coriaceous, patent to reflexed (Fig. 16c,d) .......................................................... \textit{Phlegmariurus pungentifolius}

21'. Leaves usually 10–20 mm long, herbaceous to subcoriaceous, patent to softly recurved.

22. Leaves borne in whorls of (3–)4, 2.5–3.5 mm wide (Fig. 21a,b) ......................... .......................................................... \textit{Phlegmariurus sellowianus}

22'. Leaves borne in whorls of 5–8, less than 2 mm wide.

23. Leaves of distal divisions usually terminating in a short very thin whip-like, usually curved or twisted tip (Fig. 19a-c) .......................................................... \textit{Phlegmariurus recurvifolius}

23'. Leaves of distal division without a whip-like tip.

24. Expanded leaves linear, the lamina usually twisted at the leaf base to a vertical position, ± falcately curved, to 1 mm wide, 8–12-seriate (Fig. 12a-c) ......................... .......................................................... \textit{Phlegmariurus martii}

24'. Expanded leaves ovate-lanceolate to linear-lanceolate or narrowly ovate, 1–2(–3) mm wide, not continuously overlapping.

1'. Plants pendulous, or initially erect with nodding to pendulous shoot apices, usually epiphytic; leaf margins smooth, not denticulate or erose. Plants epiphytic or rupestral.

25. Shoots with more or less sharply dimorphic leaves; proximal divisions with long expanded leaves; distal divisions constricted, with appressed, short, often decussate leaves; - or the entire plant covered by imbricate, short, broad, leaves.

26. Shoots with more or less sharply dimorphic leaves; proximal divisions extensive and usually branched, with long expanded leaves; distal sporangiate divisions constricted, with appressed, short, often decussate leaves.

27. Expanded leaves elliptic-oblong, 6–11 × 2.8–4 mm, usually continuously overlapping in pressed specimens (Fig. 3) .......................................................... \textit{Phlegmariurus aqualupianus}

27'. Expanded leaves linear or lanceolate to linear-lanceolate or narrowly ovate, 1–2(–3) mm wide, not continuously overlapping.

28. Expanded leaves linear, the lamina usually twisted at the leaf base to a vertical position, ± falcately curved, to 1 mm wide, 8–12-seriate (Fig. 12a-c) ......................... .......................................................... \textit{Phlegmariurus martii}

28'. Expanded leaves ovate-lanceolate to linear-lanceolate, 1.3–2(–3) mm wide, subdecussate or in irregular whorls of 3.

29. Leaves of terminal divisions variable, often with complete reduction series, and recurrent to expanded shape, decussate or subdecussate, continuously or discontinuously sporangiate, Expanded leaves of basal divisions 1.5–3 mm wide (Fig. 23a,b) .......................................................... \textit{Phlegmariurus myrsinites}

29'. Leaves of terminal divisions usually uniformly constricted, with appressed, short, often decussate leaves.
30. Flaccidly pendulous epiphytes, to 70 cm long, stems not red (Fig. 5a-c) ................................. 
   Phlegmariurus biformis
30’. Rupestral or epiphytic, scrambling to hanging, to 25 cm long, usually densely branched and 
   divericate, usually with red stems (Fig. 5d-f) ................................Phlegmariurus erythrocaulus
26’. Entire plant (or at least the terminal half) covered by imbricate, short, broad, decussate leaves, 
   or the plants sometimes with proximal divisions short and unbranched, and sometimes with few 
   expanded leaves at the very base.
31. Leaves decussate and imbricate throughout, or rarely with a few expanded, oblong or ovate, 
   opposite or spiralled leaves at the very base of the stem.
32. Constricted shoots sharply quadrangular throughout, 2–3 mm in diam. including leaves, 
   the leaves sharply carinate, expanded leaves sometimes present at the very base of the 
   plant, narrowly oblong (Fig. 9a-d) .................................Phlegmariurus quadrifariatus
32’. Constricted shoots rounded abaxially throughout, 0.7–1.5 mm in diam. including leaves, 
   the leaves carinate, expanded leaves sometimes present at the very base of the plant, 
   ovate to obovate (Fig. 9f-h) .............................................Phlegmariurus fontinaloides
31’. Leaves of proximal divisions in whorls of 3, forming 6 ranks, imbricate, upward decussate, or 
   sometimes with narrowly oblong expanded leaves at the very base of the plant, (Fig. 13a-e) 
   ....................................................................................................Phlegmariurus hexastichus
25’. Leaves uniform and expanded throughout, or gradually reduced upward, leaves of sporangiate divisions 
   usually in whorls of 3 or more.
33. Leaves, at least of proximal portions inserted singly (not in whorls) or occasionally some paired.
34. Stem strongly flexuous, bending at each leaf insertion (Fig. 8a-d)..Phlegmariurus flexibilis
34’. Stem not or very slightly flexuous.
35. Leaves of proximal divisions 13–25 × 1–2 mm (Fig. 17a-c) ........................................ 
   ............................................................................Phlegmariurus linifolius var. jenmanii
35’. Leaves of proximal divisions 5–10 × 0.4–0.7(–1) mm (Fig. 6c,d) ........................ 
   ................................................................................................Phlegmariurus capillaris
33’. Leaves borne in ± regular whorls of 3 or more.
36. Plants very slender, stems of proximal divisions less than 1 mm thick excluding leaves (dried), 
   leaves acicular to linear-subulate, less than 1 mm wide.
37. Leaves of proximal divisions linear to filiform, 7–10 mm long, not widened at the base, 
   with prominent vein abaxially and slightly revolute margins (Fig. 17d-f) ..................... 
   ..............................................................................................Phlegmariurus mollicomus
37’. Leaves of proximal divisions acicular-linear, 3–7 mm long, slightly widened at the base, 
   convex below.
38. Flaccidly pendulous epiphytes or sometimes rupestral, leaves 3–5 mm long, softly 
   herbaceous, sporangia 0.7–1 mm (Fig. 2a-c) ..........................Phlegmariurus acerosus
38’. Slender, scrambling or hanging, rupestral or sometimes epiphytic, often with strongly 
   diverging ramification, leaves 4–7 mm long, subcoriaceous, sporangia 1–1.3 mm 
   (Fig. 2d-f) ....................................................................................Phlegmariurus comans
36’. Plants slender to robust, stems of proximal divisions 1–2.5 mm thick excl. leaves (dried).
39. Leaves of proximal divisions convex abaxially and canaliculate adaxially.
40. Leaves of proximal divisions 10–20 × 1–1.5 mm, abaxially evenly rounded (Fig. 
   12d-f).......................................................................................Phlegmariurus heterocarpos
40’. Leaves of proximal divisions 3–(6–13) × 1–1.5 mm, abaxially subcarinate to 
   carinate, especially in distal divisions (Fig. 8e-g)....Phlegmariurus loefgrenianus
39’. Leaves of proximal divisions flat, or slightly convex abaxially with flat margins, or 
   slightly convex adaxially.
41. Leaves of proximal divisions 6–12 × 0.7–1 mm (Fig. 12a-c) ................................................. 
   ..............................................................................Phlegmariurus martii
41’. Leaves of proximal divisions 11–20 × 1.2–3 mm.
42. Leaves spreading to ascending or somewhat appressed, often twisting the lamina to vertical position, sporophylls ascending to appressed, usually not twisted (Fig. 17g-i) ..... *Phlegmariurus taxifolius*
42’. Leaves usually spreading to nearly perpendicular, the lamina twisted to vertical position, sporophylls usually spreading and twisted (Fig. 21c-e) ........................................... *Phlegmariurus silveirae*

**Phlegmariurus acerosus** (Sw.) B. Øllg. Rodriguésia 63(2): 480. 2012. Fig. 2a-c

Published illustrations: Øllgaard 1988: p. 91, figure 18 C.

Plants epiphytic, slender, flaccidly pendulous, at least to 70 cm long. Shoots usually gradually heterophyllous, sometimes homophyllous, 3–6 mm in diam. incl. the leaves in proximal divisions, tapers to 1–3(–6) mm in distal divisions. Stems excl. leaves 0.6–1 mm thick at the base, tapering to ca. 0.3–0.5 mm upward, somewhat concealed by the leaves, pale greenish to stramineous, at least to 10 times dichotomous, usually densely, unilaterally or omnilaterally sporangiate in separate, periodically produced zones of the distal divisions, or continuously sporangiate from 15–30 cm above the base and upward. Leaves gradually modified along the stems. Leaves of proximal divisions densely crowded, borne in irregular alternating whorls of 6–7, these 0.5–2 mm apart, forming 12–14 indistinct longitudinal ranks, ascending and upward curved to appressed or somewhat secund, acicular-filiform, narrowly and prominently decurrent, 3.5–5 mm long, 0.2–0.4 mm wide just above the widened base, soft herbaceous to subcoriaceous, convex below, canaliculate above, with involute margins. Vegetative leaves of distal constricted divisions borne in irregular whorls of 4–6, these 0.5–2 mm apart, forming 8–12 indistinct longitudinal ranks, ascending to closely appressed, acicular-filiform to linear-lanceolate, 2–4 mm long, otherwise conform. Sporophylls borne in irregular, alternating whorls of 3–5, conform, or shorter and wider, linear–lanceolate and long acuminate to lanceolate, usually appressed, 1.5–4 × 0.3–0.8 mm, rounded to subcarinate abaxially. Sporangia 0.7–1 mm in diam.

Distribution and habitats: West Indies, Guatemala, Costa Rica, Panamá, northern South America, south to Ecuador and Bolivia and southeastern Brazil, with one record for Amazonia [Prov Rio Negro ad Egam passim, 1819, *Martius* s.n. (M)].

Habitats: Epiphytic and sometimes epilithic in montane and cloud forest in the states of Amazonas, Bahia, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Rio Grande do Sul, and Santa Catarina, alt. ca. 300–2,600 m, the low altitudes in the southern part of the range.

Notes: *Phlegmariurus acerosus* has often been referred to *Lycopodium verticillatum* L. f. or *Lycopodium setaceum* Lam., both of which are based on material from Réunion Island, and are considered synonymous. The plants from the Old World referred to *Lycopodium verticillatum* resemble *P. acerosus*, but differ in a more robust growth habit, usually longer and more crowded leaves, and usually more densely and omnilaterally sporangiate distal divisions. However, molecular data (Wikström & Kenrick 2000) indicate that the group of *P. acerosus* belongs to a purely American clade, and the group of *Lycopodium verticillatum* is purely Old World.

*Phlegmariurus acerosus* is variable with respect to leaf size and direction. In some collections, the shoots are very narrow with short, appressed leaves, and in others they are wider with longer and patent-ascending leaves. It rather closely resembles shaded forms of *P. comans* (Nessel) B. Øllg., that differ being generally larger, shorter, and more robust, apparently as a response more exposed habitats.

Figure 2 – a-c. Phlegmariurus acerosus – a. growth habit; b. leaves of proximal division; c. distal sporangiate division. d-f. Phlegmariurus comans – d. growth habit; e. leaves of proximal division; f. distal sporangiate division. (a-c. Ecuador, Quinindé, Holdridge 1652 (US); d-f. Brazil, Serra do Itatiaia, Ule 3537 (HBG)).
Distribution and habitats: West Indies, Colombia, Venezuela, Guyana, Brazil; wet premontane and cloud forest, alt. 500–1,800 m. Brazil, know only from Minas Gerais state. Specimens studied: BRAZIL. MINAS GERAIS: Santa Maria do Salto, Distrito de Talismã, Fazenda Duas Barras, close to divisa with state of Bahia, 750–850 m, 9.X.2003, Salino et al. 9192 (BHCB); dense humid montane forest, epiphyte at 1.5 m; 850–1,000 m, Salino et al. 10052 (BHCB).

Phlegmariurus badinianus (B. Øllg. & P.G. Windisch) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 4a-c


Plants terrestrial, with short prostrate juvenating basal shoots, from which stiffly erect, well spaced to somewhat aggregated, simple or to twice forked, to 25 cm tall, finger-like, aerial shoots arise. Aerial shoots arise. Aerial shoots homophyllous or almost so, sometimes with gradually shorter leaves upward, gradually tapering from 6–20 mm in diam. incl. leaves at the base, to 4–10 mm near the apex. Stem of aerial branches excl. leaves 2–3 mm thick throughout, almost completely concealed by leaves. Leaves of aerial shoots borne in irregular alternating whorls of 4–6, these 1.5–3 mm apart, forming 8–12 indistinct or sometimes regular longitudinal ranks, spreading to arcuate-appressed at the base, upward appressed, slightly to strongly arcuate, linear-lanceolate to lanceolate, (4–)5–9 × 1.3–2 mm, abaxially convex and evenly rounded, or with a slightly prominent veinal ridge, with or without a slightly prominent basal swelling (air sac), with sclerified, minutely evenly rugose to erose-verruculate margins, green, soft-herbaceous to subcoriaceous, dull to somewhat lustrous. Sporangia ca. 2 mm wide.


Related to Phlegmariurus saururus (Lam.) B. Øllg., from which it may be distinguished by its more slender growth habit, smaller dimensions, the very loosely aggregated aerial shoots without squeezed and etiolated leaves at the base of the...
Figure 3 – *Phlegmariurus aqualupianus* – growth habit. (Brazil, Minas Gerais: Santa Maria do Salto, Distrito de Talismã, Faz. Duas Barras, 800 m, A. Salino et al. 9192 (BHC))
aerial shoots. Also the leaf margins are more irregularly uneven than usual for *P. saururus*.


Plants epiphytic, delicate, pendulous, at least to 70 cm long. Shoots heterophyllous. Proximal divisions, to 15–30 cm from the base, ca. 12–25 mm in diam. incl. the expanded leaves. Distal divisions abruptly constricted to ca. 1 mm in diam. incl. the imbricate, reduced leaves, to 25 cm long, subterete. Stems excl. leaves 0.5–0.8(–1) mm thick at the base, upward tapering to ca. 0.3–0.5 mm, greenish, rarely reddish tinged, at least to 10 times dichotomous. Expanded leaves of proximal divisions decussate, subdecussate or alternate, the leaf pairs 1.5–5 mm apart, widely spaced in alternate-leaved stem portions, perpendicular to the stem to falcately ascending, lanceolate to linear-lanceolate, usually widest just above the leaf base to ca. one-third from the base, straight to slightly falcately curved, 7–15 × 1.3–2.3 mm, softly to firmly herbaceous, with flat to slightly revolute margins, the lamina twisted to vertical position from the base. Leaves of constricted distal divisions decussate or subdecussate, the leaf pairs ca. 1–2 mm apart, usually densely sporangiate throughout, appressed and clasping with their margins, abaxially rounded to indistinctly carinate, widely ovate to almost orbicular, acute to mucronate, 1–1.5(–2) × 1(–1.5) mm, equalling or slightly exceeding the sporangia, with smooth to slightly uneven margins. Sporangia 0.7–1(–1.3) mm in diam.

Distribution and habitats: Endemic, but closely related to the Andean *Phlegmariurus phyllicifolius* (Poiret) B. Øllg. Also related to *Phlegmariurus erythrocaulos* (Féc.) B. Øllg., see there for comparison. A slender epiphyte from sheltered situations in wet montane forest, alt. 850–2,400 m. States of Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, and Santa Catarina.


Figure 4 – a-c. Phlegmariurus badinianus – a. growth habit; b. apex of erect branch; c. two sporangiate leaves. d-f. Phlegmariurus itambensis – d. growth habit; e. part of proximal division; f. sporangiate shoot apex. (a-c. Brazil, Minas Gerais, Serra do Caparaó, Windisch et al. 4971 (AAU); d-f. Brazil, Minas Gerais Serra do Espinhaço, Summit of Pico do Itambé, Anderson et al. 35783 (NY)).
red colour lacking in some collections. Only one growth habit. Stem coloration is variable, the linifolius Brazil known only from the Territory of Roraima. Tropical South America. South to Bolivia. In epiphyte in wet forest. Central America, Northern France et al: BRAZIL. RORAIMA: Rio URARICOEARA, VICINITY OF UAICÁ AIRSTRIP, 3.XII.1973, PHLEGMARIIURUS CHRIStII (SILVEIRA) B. ØLLG., Rodriguésia 63(2): 480. 2012. Specimen studied with red. Sporangia 0.7–1 mm in diam. Lamina base, or sometimes the entire leaf tinged with obscure to somewhat prominent vein above. or slightly convex adaxially, soft-herbaceous, or half, 5–10(–12) linear-lanceolate, widest in the middle or the basal with strongly twisted, often deflexed lamina base, linear-lanceolate, widest in the middle or the basal half, 5–10(–12) × 0.4–0.7(–1) mm, almost flat, or slightly convex adaxially, soft-herbaceous, with obscure to somewhat prominent vein above. Lamina base, or sometimes the entire leaf tinged with red. Sporangia 0.7–1 mm in diam. Distribution and habitats: Pendulous epiphyte in wet forest. Central America, Northern Tropical South America. South to Bolivia. In Brazil known only from the Territory of Roraima. Apparently closely related to Phlegmariurus linifolius (L.) B. Øllg. Differs in the more delicate growth habit. Stem coloration is variable, the red colour lacking in some collections. Only one Brazilian collection known. Specimen studied: BRAZIL. RORAIMA: RIO URARICOEARA, VICINITY OF UAICÁ AIRSTRIP, 3.XII.1973, PRANCE et al., 20006 (NY).
Figure 5 – a-c. Phlegmariurus bifformis – a. growth habit; b. expanded leaves of proximal division; c. distal sporangiate division. d-f. Phlegmariurus erythrocaulos – d. growth habit; e. expanded leaves of proximal division; f. distal sporangiate division. (a-c. Brazil, Santa Catarina, Morro do Cambirela, parte W, Pahoça, Bresolin 447 (FLOR); d-f. Brazil, Rio de Janeiro, Planalto of Itatiaia, vicinity of Agulhas Negras, near Piedra Atar, Tryon 6686 (AAU)).
Phlegmariurus christii generally belongs to a higher altitude range than does P. reflexus, but the two species are often found growing together.

The leaf margin characters of Phlegmariurus christii are somewhat variable. Both in slender and more robust individuals the leaf margin teeth may be remote to very dense. The type of Urostachys organosanus has few teeth, while the type of P. christii has dense teeth. See Phlegmariurus rostrifolius (Silveira) B. Øllg. for a discussion of its affinity with the present species.


Serra do Itaítaia, 2,300 m, IX.1913, Brade 6550 (HB, NY, S, SP). Serra dos Orgãos, Pedra do Sino, Campo, 2,200 m, 31.VII.1940, Brade 16526.2 (AAU, CESI, RB). Corcovado, 700 m, v. Luetzelburg 13422 (M). Teresópolis, Pedra do Sino, 2,000 m, 8.9.1929, Brade 9632A (RB). SERRA DO ITATIAIA, 2,300 m, IX.1913, Brade 6550 (HB, US).

SANTA CATARINA: Passa Quatro, Pico do Muro, 1,800 m, Reitz & Klein 10494 (HBR). SÃO PAULO: Campos do Jordão, road to São José dos Alpes, ca. 10 km from Horto Florestal, 1,800 m, Windisch et al. 4996 (AAU, HB). Serra do Mar, road Cunha-Parati, 1,450 m, Windisch et al. 5007 (AAU).


Plants epiphytic or rupestral, slender, pendulous, or scrambling-hanging over rocks, often with strongly diverging dichotomies, at least to 60 cm long. Shoots homophyllous, or gradually heterophyllous, 3–8(–12) mm in diam. incl. the leaves in proximal divisions, sometimes tapering to 2–6 mm in distal divisions. Stems excl. leaves 0.8–1 mm thick at the base, tapering to ca. 0.4–0.7 mm upward, largely concealed by the leaves, pale greenish to stramineous, at least to 10 times dichotomous, usually densely omnilaterally sporangiate in repeated, short, periodically produced zones of the distal divisions from 5–15 cm above the base and upward. Leaves gradually slightly modified along the stems. Leaves of proximal divisions densely crowded, borne in irregular alternating whorls of 5–6, these 0.5–2 mm apart, forming 10–12 indistinct longitudinal rankings, ascending to closely imbricate or somewhat secund, accicular to linear-subulate, narrowly and prominently decurrent, 4–7 × (0.3–)0.4–0.6 mm wide just above the widened leaf base, firmly herbaceous to coriaceous, somewhat lustrous, convex below, canaliculate above. Vegetative leaves of distal constricted divisions borne in irregular whorls of 3–4, forming 6–8 indistinct longitudinal rankings, essentially conform, but usually slightly shorter, 3–5 mm long. Sporangiate leaves shorter and wider, or sometimes conform, usually lanceolate to linear-lanceolate and long acuminate, patent to appressed, (2–)3–6 × 0.5–0.8(–1) mm, abaxially convex. Sporangia ca. 1–1.3 mm in diam.

Distribution and habitats: Endemic. Epiphytic and rupestral in high altitude montane and cloud forest in the states of Minas Gerais, Rio de Janeiro (Serra da Mantiqueira, and Serra dos Orgãos), São Paulo, and Paraná, alt. ca. 1,200–2,400 m, the lower altitudes in the southern states.

More compact and shorter, but otherwise approximately twice as large in all parts as Phlegmariurus acerosus in the same area. In the southern states some of the material has thinner leaves and slightly thinner stems. The type material of Lycopodium verticillatum var. apertum represents a shaded, lax, epiphytic form of the species.

2,400 m, Brade 6509 (HB, S, US). Planalto do Itatiaia, between Prateleiras and Pedra Assentada, 2,300 m, Tryon & Tryon 6699 (HB, F, GH). Itatiaia, Pedra Assentada, 2,300 m, Brade 15564 (AAU). Resende, S face of Mt. Itatiaia, above Macieiras, 2,020 m, Eiten & Eiten 7610 (K, SP, UB, US). Serra dos Órgãos, Pedra Assú, 2,000 m, Brade 16509 (AAU, RB). SÃO PAULO: Campos do Jordão, Mattos 15907 (SP).

**Phlegmariurus deminuens** (Herter) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 7a,b


Plants terrestrial, stiffly erect, to ca. 30 cm tall, to 4–6 times dichotomous, sometimes with densely aggregated shoots from the base, but without prostrate basal, juvenating shoots. Shoots homophyllous, or with gradually shorter leaves upward, 10–15 mm in diam. incl. leaves

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**Figure 6** – a-b. *Phlegmariurus dichotomus* – a. growth habit; b. terminal sporangiate division. c-d. *Phlegmariurus capillaris* – c. growth habit; d. distal sporangiate division. (a-b. Ecuador, Quinindé, Holdridge 1654 (GH); c-d. Colombia, Popoyán, Hartweg 1464 (P)).
at the base, usually tapering to 5–8 mm upward, sporangiate from ca. 10 cm above the base and upward. Stem excl. leaves 3–5 mm thick at the base, upward tapering to ca. 1–3 mm, completely concealed by leaves. Leaves densely crowded and usually closely appressed, borne in alternating whorls of 6–ca. 8, these ca. 1 mm apart, forming ca. 12–ca. 16 indistinct longitudinal ranks, straight to slightly upward curved, linear-subulate to linear-lanceolate, 8–14 × 1–1.3 mm, adaxially concave with slightly prominent vein, abaxially convex and rounded with indistinct to slightly prominent vein, soft-herbaceous to subcoriaceous, dull to lustrous, with smooth margins. Leaves of upper, densely sporangiate borne in alternating whorls of 6–7, these ca. 1 mm apart, forming 12–14 longitudinal ranks, linear-lanceolate to lanceolate, 4–7 × ca. 1 mm, otherwise conform. Sporangia ca. 1.5–2 mm wide.

Distribution and habitats: Endemic. Rare, high altitude campos in the states of Minas Gerais and Rio de Janeiro, alt. 1,000–1,800 m.

With erect fingerlike distal divisions, in which the leaves are appressed, and strongly convex abaxially. Related to *Phlegmariurus treitubensis* (Silveira) B. Øllg. and *P. regnellii* (Maxon) B. Øllg., but softer and more slender in most parts, and apparently a more extreme adaptation to exposed growth conditions than those. Several of the collections of this species have been badly damaged by insects.

**Reference specimens** (14 collections studied): BRAZIL. MINAS GERAIS: Serra de Itibipoca, Pico do Pão, Arento da Serra da Lavras, SW, 1,580–1,600 m, Sucre & Krieger 6766 (AAU, RB). Serra do Picuí, in campus elevatis, 1,800 m, Schwake 5293 (P), Lima Duarte, P.E. Itibipoca, Pico do Pão, 1,664 m, Almeida et al. 1154 (BHCB). RIO DE JANEIRO: Itaiaia, Pedra do Altar, 2,400 m, Brade 15562 (RB).

**Phlegmariurus dichotomus** (Jacq.) W.H. Wagner, Novon 3: 305. 1993. - Fig. 6a,b


Published illustrations: Lellinger, 1989: fig. 23; Øllgaard, 1988: p. 95 fig. 19 D.

Plants usually epiphytic, pendulous or recurved from an erect base, lax to subrigid, sparsely to densely and spreadingly branched, usually to 25–50 cm long. Shoots homophyllous, almost equally thick throughout, 20–25 mm in diam. incl. leaves near the base, usually tapering to (10–)15 mm in densely sporangiate distal divisions. Stem excl. leaves 2–3 mm thick at the base, sometimes tapering to 1.5–2 mm, usually almost concealed by leaves, ridged by decurrent leaf bases, sporangiate from 5–15 cm above the base and upward, usually 3–5 times dichotomous. Leaves borne in alternating whorls of 5–6, these 1–2 mm apart, forming 10–12 indistinct longitudinal ranks, spreading to ascending, usually somewhat obliquely falcate, in distal divisions ascending to somewhat appressed, or appressed
Figure 7 – a-b. Phlegmariurus deminuens – a. growth habit; b. distal sporangiate division. c-d. Phlegmariurus rostrifolius – c. growth habit; d. distal sporangiate division. e-g. Phlegmariurus christii – e. growth habit; f. middle sporangiate division; g. sporangiate leaf. (a-b. Holotype, Brazil, Minas Gerais, A. de Saint Hilaire D 248 (P); c-d. Brazil, Minas Gerais, Serra da Papagaio, A. Silveira 2605 (P); e-g. Brazil, Rio de Janeiro, Serra dos Orgãos, Pedra do Sini, Brade 16526 (RB)).
throughout, linear-subulate, gradually tapering from the base, (8–)10–15(–17) × 0.7–1 mm, almost flat, with slightly prominent vein above, with flat or slightly revolute margins, abaxially with slightly to sharply prominent vein, soft-herbaceous, usually twisted at the base. Leaf bases long and prominently decurrent, green, as wide as, or wider than the lamina, with sharply prominent vein. Sporangia 1–1.5 mm in diam.

Distribution and habitats: Northern Tropical America. Florida, West Indies, Central America, Northern South America, Galapagos Islands, Brazil (Roraima, Amapá, Acre, Mato Grosso, Ceará, Pará, Rondonia, Roraima), Amazonian Bolivia.

Epiphytic in riverine, lowland and premontane forests, 0–1,400 m.

The number of synonyms of this species reflects its variability throughout its range. Closer study of the material referred to this species may show the presence of more than one taxon, especially in the northern part of the range, because there is considerable variation in the thickness of stems, leaf length and direction, and compactness of the plants. However, the correlation of the variation with growth conditions is poorly known at this point.


Closely related to Phlegmariurus biformis, P. phyllicifolius (Desv. ex Poir.) B. Øllg., and other members of the P. myrsinites group, and apparently adapted and restricted to open epiphytic, or more commonly rupestral or terrestrial habitats in “campo de altitude” on Mount Itatiaia and Passa Quatro, Campo do Muro and Itaguará (Minas Gerais), alt. 1,850–2,400 m. It is more robust, more divergently branched, slightly more coriaceous-leaved, and more red-colored than Phlegmariurus biformis.

Reference specimens (15 collections studied): BRAZIL. BAHIA: Rio de Contas, Pico das Almas, 1,850 m, Matos 1052 (photo <http://www.fernsoftheworld.com/2014/01/17/phlegmariurus-erythrocaulon>). MINAS GERAIS: Passa Quatro, Campo do Muro, 1,900 m, Brade 19102 (RB). Catas Altas, RPPN Santuário do Caracá, Pico do Sol, 1,865 m, Oliveira 515 (BHCB, photo AAU). RIO DE JANEIRO: Itatiaia, vicinity of Agulhas Negras, near Preda Altar, 2,300 m, Tryon &

Rodriguésia 70: e01932017. 2019
Figure 8 – a-d. *Phlegmariurus flexibilis* – a. growth habit; b. leaves from proximal division; c. growth habit of fertile plant; d. sporangiate leaves from distal division. e-g. *Phlegmariurus loefgrenianus* – e. growth habit; f. leaves from proximal division; g. sporangiate leaves of distal division. (a-d. Brazil, Paraná, Jacarehy, Dusén 14762 (S); e-g. Brazil, São Paulo, Cidade Jardim, São Paulo, Gehrt s.n.; Bonn-Nessel 368a (SP-27049)).
**Phlegmariurus flexibilis** (Fée) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 8a-d


Plants epiphytic, pendulous, usually with flaccidly hanging divisions, at least to 70 cm long, the distal divisions often aggregated in fasciculate clusters. Shoots homophyllous or gradually heterophyllous, equally thick throughout, 15–35 mm in diam. incl. leaves, or gradually tapering to 6–15 mm in diam. in distal, densely sporangiate divisions. Stems excl. leaves 0.4–0.8 mm thick at the base, slightly tapering upward, slightly to strongly flexuous, making a sharp bend at each leaf attachment, pale greenish to red tinged, sporangiate strongly flexuous, making a sharp bend at each leaf at the base, slightly tapering upward, slightly to 10 times dichotomous. Leaves of proximal from 5–30 cm above the base and upward, at least to a twist of the lamina base. Sporangia ca. 1.5 mm in diam.

Distribution and habitats: Endemic. Epiphytic, especially in montane forest in the states of Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, and Santa Catarina, alt. 30–1,350 m, the lower altitudes in the southern part of the range.

A close relative of *Phlegmariurus linifolius* (L.) B. Øllg., from which it is easily distinguished by the reddish, thin, usually strongly flexuous stem. In Atlantic Brazil *Phlegmariurus flexibilis* is replaced by *P. linifolius* ssp. *jenmanii* (Underw. & F. E. Lloyd) B. Øllg. & P.G. Windisch, in Northern Espírito Santo.

The syntypes of *Lycopodium linifolium* L. var. *sanguineum* Spring include material belonging to *Phlegmariurus flexibilis*, but no specimens annotated by Spring were seen.


Figure 9 – a-d. *Phlegmariurus quadrifariatus* – a. growth habit; b. proximal division with reduced leaves; c. Brazil, Rio de Janeiro, Morro da Fazenda, Tijuca, Glaziou 5219 (P), growth habit, proximal divisions with expanded leaves; d. distal division with sporangiate leaves. e-h. *Phlegmariurus fontinaloides* – e. growth habit of plant with expanded leaves in proximal divisions; f. Brazil, Paraná, Itaiacoca, 1904, Dusén s.n. (P), growth habit of plant with constricted proximal divisions; g. constricted proximal division; h. sporangiate distal division. (a-d. Brazil, Rio de Janeiro, Itatiaia, Rio Campo Belo, 900 m, Brade 21455 (AAU); e-h. Brazil, Rio de Janeiro: Pico de Papagaio, forest of Tijuca, Brade 8615 (AAU)).
Phlegmariurus fontinaloides (Spring) B. Øllg., Rodriguesia 63(2): 480. 2012.  [fig. 9e-h]
Published illustrations: Øllgaard 1992: p. 704, fig. 11.

Plants epiphytic, lax and pendulous, at least to 70 cm long, at least to 10 times dichotomous. Shoots very slender, usually covered by small imbricate leaves throughout, usually homophyllous or with gradually smaller leaves in distal divisions, but sometimes with longer and wider expanded leaves in the proximal divisions; sporangiate in separate, seasonally produced zones or continuously sporangiate from 10–50 cm above the base and upward. Constricted shoots incl. leaves terete throughout, 0.7–1.5 mm in diam. incl. leaves at the base, toward the apex sometimes slightly thickening, 1–2 mm in diam. Stem excl. leaves 0.7–1(1.3) mm thick at the base, usually bright red, tapering to 0.3–0.5 mm in distal divisions. Expanded leaves, if present, decussate, closely situated and usually continuously overlapping, elliptic to ovate with acute to acuminate or mucronulate apex and cuneate leaf base, usually 4–5(–6) × 2–2.5(–3) mm, flat, ascending to appressed, with smooth to minutely denticulate-verruculate margins, often reddish. Leaves of proximal and upper vegetative constricted divisions decussate (rarely a few whorls of 3 leaves present in approx. 1 cm of the stem base), the leaf pairs (1–)1.5–2(–4) mm apart, usually appressed or with slightly diverging apex, lanceolate-ovate to widely ovate, clasping, with short-decurrent leaf-base margins, acute to subobtuse, often with pale margins and apex, abaxially evenly rounded, softly to firmly herbaceous, dull to lustrous, 1.5–2.5 × 1–1.3(–1.5) mm, with smooth to minutely denticulate-verruculate margins. Sporangiate leaves usually as long as wide, 1–1.5 mm long and wide, equaling or slightly exceeding the sporangia. Sporangia ca. 1 mm wide.


Perhaps related to Phlegmariurus hexastichus (B. Øllg. & P.G. Windisch) B. Øllg. and P. quadrifariatus (Bory) B. Øllg., but much more delicate with thin, red stems, and small, decussate, dorsally rounded, imbricate leaves throughout in the wholly constricted individuals. The vegetative and sporangiate leaves essentially similar. Some collections with only expanded leaves may reflect strongly shaded growth conditions.

Figure 10 – a-c. *Phlegmariumus friburgensis* – a. growth habit; b. distal sporangiate division; c. middle sporangiate division. d-e. *Phlegmariumus nudus* – d. growth habit, the proximal part with two new sprouting shoots; e. sporangiate division. [a-b. Glaziou 4476 (P); c. A.P. Duarte 13961 (AAU); d-e. Luederwaldt s.n. (SP18.082)].
Phlegmariurus friburgensis (Nessel) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 10a-c

Plants terrestrial, erect or ascending from a decumbent base, soft, usually forming small loose clumps, 10–30–(40) cm tall. Shoots homophyllous, almost equally thick throughout, 7–13 mm in diam. incl. leaves. Stems excl. leaves or almost smooth, sporangiate from 5–30 cm above the base and upward, usually 2–4 times dichotomous. Leaves borne in alternating, often irregular and oblique, whorls of 6–7, these ca. 1–2 mm apart, forming 12(–14) longitudinal ranks, ascending to spreading or sharply reflexed, straight to strongly recurved, linear-subulate to linear-lanceolate, widest at the base to below the middle, 4,5–6 × 0,5–0,8 mm, subcoriaceous, or soft-herbaceous in shaded individuals, adaxially convex and usually somewhat lustrous, abaxially slightly concave to convex, with obscure to widely prominent vein, the vein usually shrunk (sulcate) when dried, with somewhat thick, flat to revolute, entirely smooth to very sparsely denticulate margins. Leaf bases often somewhat decurrent. Sporangia 1.5–2 mm thick at the base, sometimes tapering to ca. 1.5 mm upward, pale greenish white. Leaves borne in more or less regular, often oblique, alternating whors of 4–5(–6), these 2–4 mm apart, forming 8–10(–12) indistinct longitudinal ranks, spreading to sometimes sharply reflexed, linear-lanceolate, widest just below the middle, 8–11 × 1.5–2 mm, not twisted at base, prominently decurrent, adaxially flat to somewhat convex (dried), or slightly downward folded along the vein, abaxially with slightly prominent vein, with pale, irregularly denticulate margins. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic. Rare, at higher elevations (1,450–1,700 m) in the states of Mato Grosso (?), Minas Gerais and Rio de Janeiro (Serra dos Orgãos, Nova Friburgo), in montane forest and campo vegetation. One specimen, Ule 4666 (P) indicates the state of Santa Catarina as origin, but the same number from HBG indicates Nova Friburgo. The same sheet (HBG) has in its more slender stems and more coriaceous leaves with most often entirely smooth margins.


Phlegmariurus hemleri (Nessel) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 11a,b

Plants terrestrial, ascending to erect from a decumbent base, to ca. 35 cm tall or to ca. 60 cm long, sparsely branched, to 4 times dichotomous. Shoots homophyllous, equally thick throughout, ca.15–25 mm in diam. incl. leaves (depending on leaf direction), sporangiate from ca. 20–40 cm above the stem base and upward, often in separate, seasonally produced zones. Stems excl. leaves 2–4 mm thick at the base, sometimes tapering to ca. 1.5 mm upward, pale greenish white. Leaves borne in more or less regular, often oblique, alternating whors of 4–5(–6), these 2–4 mm apart, forming 8–10(–12) indistinct longitudinal ranks, spreading to sometimes sharply reflexed, linear-lanceolate, widest just below the middle, 8–11 × 1.5–2 mm, not twisted at base, prominently decurrent, adaxially flat to somewhat convex (dried), or slightly downward folded along the vein, abaxially with slightly prominent vein, with pale, irregularly denticulate margins. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic. Rare, known from the states of Minas Gerais, Rio de Janeiro, and Paraná.

Phlegmariurus friburgensis is closely related to P. reflexus (Lam.) B. Øllg., especially the small form of that species, of which it may represent a high-altitude form. It differs from P. reflexus mainly

Figure 11 – a-b. *Phlegmariurus hemleri*. Brazil, Rio de Janeiro, Arredores da Capital Federal, *Hemler* s.n. (Bonn-Nessel 167) – a. growth habit; b. sporangiate division.
material apparently from Serra do Ouro Preto (leg. Schwacke). Hartmann 106 cited in the protologue, from Mato Grosso, Cuyabá, 1909, was not seen. It is probably a mislabelled specimen.

**Phlegmariurus hemleri** superficially resembles *P. sellowianus* (Herter) B. Øllg., but is easily distinguished by the denticulate leaf margins. The spores are well developed. Presumably belongs in shaded high-altitude habitats in forest.


**Phlegmariurus heterocarpos** (Fée) B. Øllg., Rodriguésia 63(2): 480. 2012 [as heterocarpon].

Fig. 12d-f


Epiphytic, lax and pendulous to spreading, or sometimes recurved from an erect and somewhat rigid stem base, at least to 60 cm long. Shoots more or less abruptly tapering from ca. 20–35 mm in diam. incl. leaves in proximal divisions, to (4–)5–15 mm in diam. in distal divisions, sometimes not, or only slightly tapering (juvenile or tardily sporangiate individuals); homophyllous or gradually heterophyllous, sporangiate from ca. 15–30 cm above the base and upward. Stems excl. leaves 1.5–2 mm thick at the base, tapering to 0.5–1.5 mm upward, prominently ridged by decurrent leaf bases, pale greenish to brownish, at least to 8 times dichotomous. Leaves usually reduced and modified upward, borne in alternating whorls or irregular low spirals of 3 or 4, forming 6–8 indistinct longitudinal ranks, the whorls 1.5–3 mm apart in proximal divisions, upward sometimes 1–2 mm apart. Leaves of proximal divisions spreading to ascending, usually slightly falcately upward curved, the lamina twisted to a vertical position from the base, linear to narrowly linear-lanceolate, widest at or near the base, evenly tapering, widely joined, somewhat clasping and seemingly adnate-decurrent on the stem, with pale leaf base center and long-decurrent green leaf base margins, soft-herbaceous to subcoriaceous, 10–20 × 1–1.5 mm, slightly concave to canaliculate adaxially, with flat or slightly involute, smooth margins, abaxially convex and evenly rounded, with evident to somewhat prominent vein. Sporangiate leaves of middle and distal divisions borne in alternating irregular whorls of 3–4, rarely decussate, conform, or gradually shorter, with a short, strongly widened, abaxially rounded (rarely subcarinate), clasping base, with a prominent vein, and usually an abruptly narrowed lamina beyond the base; lamina variable, conform to leaves of proximal divisions, to highly reduced to a short, narrow, involute cusp, 3.5–15 × 1.5–2 mm. Sporangia 1.5–2.2 mm wide.

**Distribution and habitats**: Pendulous epiphyte, sometimes epilithic; montane forest, and *Araucaria* formations in the states of Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, and in Argentina (Missiones), alt. 500–1,900 m, the lower altitudes in the southern parts of the range.
Figure 12 – a-c. Phlegmariurus martii – a. growth habit; b. leaves of proximal division; c. distal sporangiate division. – d-f. Phlegmariurus heterocarpos – d. growth habit; e. leaves of proximal division; f. distal sporangiate division. (a-c. Brazil, Espirito Santo, Mun. Castelo, Braço do Sul, Brade 19311 (SP); d-f. Brazil, Sao Paulo, Dávidas, road Mayrink-Santos, Gehrt SP 27499 (SP))
Phlegmariurus heterocarpos appears to be related to *P. loefgrenianus* (Silveira) B. Øllg. and *P. silveirae* (Nessel) B. Øllg.. In some characters *Phlegmariurus loefgrenianus* seems intermediate between *P. heterocarpos* and species in the *P. quadrifariatus* group. And *P. silveirae* appears intermediate between *P. heterocarpos* and *P. taxifolius* (Sw.) A. Löve & D. Löve.


Fig. 13a-e *Huperzia hexasticha* B. Øllg. & P.G. Windisch, *Bradea* 5: 11, fig. 2. 1987. - Type: BRAZIL: Estado de São Paulo: Campos do Jordão, estrada a São José dos Alpes, a ca. 12 km do Horto Florestal, matinha nebular, ca. 1,850 m alt., *Windisch et al. 4995* (holotype HB, isotypes AAU, GH, SP).


Published illustrations: Øllgaard & Windisch 1987, fig. 2.

Plants epiphytic, initially recurved from an erect base, ultimately lax and pendulous, at least to 70 cm long, at least to 8 times dichotomous, sometimes forming large, heavy clumps. Shoots narrow, usually covered by small imbricate leaves throughout, usually homophyllous or with gradually smaller leaves in distal divisions, but sometimes with long expanded leaves in short portions of the proximal divisions, sporangiate in separate, seasonally produced zones from (7–)20–50 cm above the base and upward. Constricted shoots incl. leaves terete or bluntly angular at base, 1.5–2.5(–3) mm in diam. incl. leaves, distally becoming bluntly to sharply quadrangular, 1–2 mm in diam. Stem excl. leaves 1.5–2 mm thick at the base, not red, tapering to 0.5–1 mm in distal divisions. Expanded leaves (if present), linear to oblanceolate, 5–15 × 1.5–2.5 mm, with short-acute to obtuse apex, flat, with slightly revolute margins, spreading to ascending; transitional leaves to imbricate leaves intermediate, loosely appressed. Leaves of proximal constricted divisions usually borne in alternating whorls of 3, these 1–3 mm apart, forming 6 longitudinal ranks, or sometimes decussate, usually closely appressed, sometimes ascending, ovate to widely triangular-ovate, acute or subacute, abaxially rounded or with a blunt, prominent veinial ridge or carina, sometimes with sunken vein in the leaf base, widely and prominently long-decurrent, coriaceous, dull to lustrous, 1.5–2(–3) × 1.5–2 mm, with smooth to somewhat unevenly erose margins. Vegetative
Figure 13 – a-e. Phlegmariorus hexastichus – a. growth habit of entirely constricted plant; b. constricted proximal division; c. growth habit of plants with expanded leaves in proximal divisions; d. basal division with expanded leaves; e. distal sporangiate division. (a-b. Brazil, Rio de Janeiro, Glaziou 2794 (BR); c-e. Brazil, Faz. do Tacoaral, en montant aux Campos Brejos, Glaziou 7494 (C)).
leaves of distal divisions decussate, smaller, 1.5–2 × 1–1.5 mm, often more sharply carinate, otherwise conform. Sporangiate leaves of densely sporangiate divisions often wider than long, 1–1.5 × 1–1.3 mm, equalling or slightly exceeding the sporangia. Sporangia ca. 1–1.3 mm wide.


The closest relatives of this species are Phlegmariurus quadrijariatus, and P. fontinaloides. Phlegmariurus hexastichus differs from the former of these by the terete or bluntly angular proximal divisions, with the leaves usually 6-seriate. The proximal divisions of P. quadrijariatus are sharply quadrangular. Phlegmariurus fontinaloides differs from both by the very thin, usually red stems of proximal divisions, with small decussate leaves. Phlegmariurus hexastichus seems to be as common or more common than its nearest relatives.


Plants terrestrial, ascending to stiffly erect from a decumbent base, to 60 cm tall, sparsely branched, to 3(–5) times dichotomous. Shoots homophyllous, equally thick throughout, 10–35 mm in diam. incl. leaves, sporangiate from ca 20 cm above the ground, often in separate zones. Stems excl. leaves 2.5–4 mm thick at the base, tapering to ca 2–3 mm upward. Leaves borne in more or less regular, often oblique, alternating whorls of 5–8, these 2–5 mm apart, forming 10–16 indistinct longitudinal ranks, spreading to reflexed, sometimes sharply reflexed and appressed to the stem, linear to linear-subulate, evenly tapering from the base or the middle, (10–)11–19 × 0.8–1.3 mm, not or rarely, twisted at base, broadly decurrent, adaxially slightly convex-slightly concave or canaliculate, with slightly prominent vein, abaxially with slightly prominent vein, with smooth, sometimes slightly revolute margins, with indistinctly to prominently and broadly decurrent leaf bases. Sporangia 1.5–2 mm wide.
Figure 14 – a-b. *Phlegmarium hippurideus* – a. growth habit; b. sporangiate division. c-d. *Phlegmarium mandiocanus* – c. growth habit; d. sporangiate division; d1. schematic transverse section of leaf. e-f. *Phlegmarium wilsonii* – e. growth habit; f. sporangiate division. (a-b. Colombia, Cauca, Sneidern 2196 (S); c-d. Langsdorff Mandioca, Brazil (P); e-f. Ecuador, Carchi, Maldonado, Holm-Nielsen et al. 6091 (AAU)).
Distribution and habitats: Central America, Greater Antilles, Andes from Venezuela south to Bolivia, and the Venezuelan and Brazilian Roraima Formation.

Upper montane forest, especially near the forest limit, usually on the forest floor, in semishade.

*Phlegmariurus hippurideus* belongs to a group of closely related taxa of montane forests in tropical America. *Phlegmariurus nudus* (Nessel) B. Øllg. is the closest relative in Brazil, and differs most conspicuously in its much smaller size. Only one Brazilian collection studied.

**Specimen studied:** BRAZIL. RORAIMA: Vira Onça, Monte Roraima, acampamento do Coati, 2,702 m, *Mota 1243* (BHCN).

*Phlegmariurus huberi* (B. Øllg.) B. Øllg., Phytotaxa 57: 16. 2012. - Fig. 15a-c


Plants terrestrial, erect or ascending to erect from a decumbent base, to ca. 40 cm tall, sparsely branched, to 4 times dichotomous. Shoots homophyllous, almost equally thick throughout, ca. 15–28 mm in diam. incl. leaves (depending on leaf direction), sporangiate from approx. 15–30 cm above the stem base and upward, often in separate, seasonally produced zones. Stems excl. leaves 1–1.5 mm thick (dried) at the base, sometimes tapering to ca. 1.5 mm upward. Leaves borne in more or less regular, or often oblique, alternating whorls of 6–8, these 1–2 mm apart, forming 12–16 indistinct longitudinal ranks, spreading to ascending, slightly to strongly recurved from an ascending leaf base, linear to linear-lanceolate, broadest near the base, 8–14 × (1–)1.2–1.6(–2) mm, adaxially flat to somewhat concave (dried), abaxially with slightly tenuis vein, usually somewhat lustrous, hypostomatic, with entirely smooth margins. Sporangia 1.5–2 mm wide.

Distribution and habitats: This species occurs in open situations on sandstone mesetas, and in swampy savannas, at 2,000–2,300 m elev. Endemic for the Venezuelan and Brazilian Roraima formation.

This seems related to *Phlegmariurus recurvifolius* (Rolleri) B. Øllg. and *P. hippurideus* (Christ) B.Øllg.). From the former it is recognized by its broader leaves that taper gradually into an acute apex. In *P. recurvifolius* the apex is protracted into a narrow, twisted, often yellowish or transparent, whip-like tip. From *P. hippurideus* is is distinguished by the broader, more densely crowded leaves, which are recurved from an ascending leaf base, and not reflexed from the very base. Only one Brazilian collection studied.

**Specimen studied:** BRAZIL. RORAIMA: Vira Onça, Monte Roraima, acampamento do Coati, 2,702 m, *Mota 1243* (BHCN).

*Phlegmariurus intermedius* (Trevis.) B. Øllg., Rodriguésia 63(2): 480. 2012. - Fig. 16a,b


Plants terrestrial or rupestral, erect or ascending from a decumbent base, or spreading-scrabbling over the ground with erect shoot apices, to 40 cm tall or to 80 cm long, at least to 10 times dichotomous, scrambling individuals usually with strongly divergent dichotomies. Shoots homophyllous, equally thick throughout, (4–)5–7(–9) mm in diam. incl. leaves, sporangiate from ca. 10–30 cm above the base, often in separate periodically produced zones. Stems excl. leaves 1–1.5 mm thick at the base, tapering to ca. 0.5–1 mm upward. Leaves borne in usually regular, alternating whorls of 5–7, these 0.5–1.5(–2) mm apart, forming 10–14 indistinct longitudinal ranks, usually uniformly strongly recurved and hook-like from an initially appressed leaf base, sometimes slightly recurved to perpendicular, linear-subsulate to linear-lanceolate, widest at or just above the base, 4–6 × 0.5–0.7 mm, not twisted, adaxially slightly concave to slightly convex, with indistinct to slightly prominent vein, abaxially with strongly and widely prominent and long-decurrent vein, with smooth margins, firmly herbaceous to subcoriaceous, usually lustrous, with distinctly prominent deciduous leaf bases. Sporangia 1–1.3 (–1.5) mm wide.

Distribution and habitats: Guadeloupe, Venezuela, Brazil (Bahia, Minas Gerais, Espírito Santo). Rupestral, rock outcrops in mountains, alt. 1,400–2,050 m.
Figure 15 – a-c. Phlegmariurus huberi – a. growth habit; b. vegetative leaf of lower division; c. sporangiate division. (Venezuela, Bolivar, Macizo de Chimantá, Apacará-tepui, Steyermark et al. 128412 (AAU)).
Resembles *Phlegmariurus frigiburgensis* in size and shape of the leaves, but deviates by the high number and strongly divergent dichotomies, and the hook-like leaves.


*Fig. 4d-f*  

Published illustrations: Òllgaard & Windisch 1987, fig. 1B.

Terrestrial, stiffly erect, forming clumps, to 28 cm tall, to 6 times dichotomous. Shoots homophyllous, or gradually with shorter leaves upward, equally thick throughout, or tapering and with fewer leaf ranks upward, 5–8 mm in diam. at the base incl. leaves, sometimes tapering to 3–4 mm upward, sporangiate from ca. 15–20 cm above the base and upward. Stem excl. leaves 2–3 mm thick at the base, upward tapering to ca. 1 mm, almost completely concealed by leaves. Leaves of proximal divisions crowded and closely imbricate, borne in alternating whorls of 4–5, these 2–3 mm apart, forming 8–10 regular longitudinal ranks, straight, lanceolate to widely triangular-lanceolate, evenly tapering, 4–5 × 1.5–2.5 mm, evenly tapering, slightly to strongly carinate, coriaceous, somewhat lustrous, with smooth or uneven to shallowly erose margins. Leaves of upper, densely sporangiate divisions borne in alternating whorls of (2–)3–4, these 1.5–2 mm apart, forming (4–)6–8 regular longitudinal ranks, ovate-lanceolate to widely triangular-ovate, acuminate, with an abaxially rounded and somewhat swollen (massive) leaf base, and usually carinate apex, or sometimes carinate throughout, 2–3 × 1.5–2 mm, coriaceous, with smooth to shallowly erose margins. Sporangia ca. 1.5 mm wide.

Distribution and habitats: Endemic. Minas Gerais. A very distinct species, which seems most closely related to *Phlegmariurus mooreanus* (Baker) B. Òllg., and *Phlegmariurus ruber* (Cham. & Schlecht.) B. Òllg., all of which occur on rather isolated high mountains in Southern and Eastern Brazil, 1,200–2,250 m. Personal observation by Ashley Field (BRI) “*P. itambensis* is an extraordinary epilith growing in some of the driest harshest quartzitic rock conditions on Itambé”.


*Fig. 17a-c*  

Published illustrations: Òllgaard 1988: p. 91 fig. 18A.

Plants epiphytic, pendulous, usually with flaccidly hanging divisions, the distal divisions often aggregated in fasciculate clusters, to 60 cm long. Shoots homophyllous or gradually heterophyllous, equally thick throughout, 20–30 (–45) mm in diam. incl. leaves, or gradually tapering to 10–15 mm in diam. in distal, densely sporangiate divisions. Stems excl. leaves 0.8–1 mm thick at the base, slightly tapering upward, almost straight
to somewhat sinuous, but not sharply flexuous, pale transparently stramineous, the vascular tissue usually visible through the cortex, sporangiate from 3–30 cm above the base and upward, to 6 times dichotomous. Leaves of proximal divisions spirally arranged, single, or in occasional pairs or whorls of 3, 0.5–3 mm apart, not predominantly whorled, forming ca. 6 indistinct longitudinal ranks, subdistant, soft-herbaceous, perpendicular to spreading-spreading, straight to slightly falcate, usually with the lamina vertical due to a twist of the lamina base, linear-lanceolate, widest in the basal third or quarter, distinctly narrowed into a petiole-like, twisted, usually perpendicular or deflected lamina base, 13–25 × 1–2 mm, flat, or with slightly revolute, smooth margins. Leaves of middle and distal divisions spirally arranged, paired or borne in irregular, alternating whors of 3, spreading to perpendicular, conform, or usually narrower, (5–)7–15(–20) × 0.7–1.5 mm, transparently to brownish green, or rarely reddish tinged. Sporangia ca. 1.5 mm in diam.

Distribution and habitats: Often in riverine forest. Throughout the Amazonian lowland region of Venezuela, Colombia, Ecuador, Peru and Bolivia, the Guayanas and Northern coastal Brazil to Bahia, Amapá, Amazonas, Pará, Rondonia, Mato Grosso, São Paulo.


*Lycopodium loefgrenianum* (Silveira) B. Øllg., Rodriguésia 63(2): 480. 2012. Fig. 8e,f


Plants epiphytic, lax and pendulous, to 80 cm long. Shoots tapering from ca. 6–15 mm in diam.incl. leaves in proximal divisions, to 2–6 mm in diam in densely sporangiate divisions of fully developed plants, sometimes not, or only slightly tapering (juvenile or tardily sporangiate individuals), homophysyllous or gradually heterophyllous, sporangiate from ca. 15–45 cm above the base and upward. Stems excl. leaves 1–2 mm thick at the base, tapering to 0.5–1 mm upward, prominently ridged by decurrent leaf bases, pale greenish to brownish, at least to 5 times dichotomous. Leaves usually reduced and modified upward, borne in alternating whors or irregular low spirals of 3(–4?), forming 6(–8?) indistinct longitudinal ranks, or subdecussate, the whors or leaf pairs 1.5–2 mm apart in proximal divisions, upward sometimes 1–2 mm apart. Leaves of proximal divisions spreading to ascending, slightly falcately upward curved to slightly recurved, the lamina twisted or not, linear to narrowly linear-lanceolate, widest at or near the base, evenly tapering, widely joined, somewhat clapping and seemingly adnate-decurrent on the stem, with pale leaf base center and long-decurrent green leaf base margins, soft-herbaceous to subcoriaceous, (3)–6–13 × 1–1.5 mm, sightly concave to canaliculate adaxially, with flat or slightly involute, smooth margins, abaxially usually subcarinate to carinate. Sporangiate leaves of middle and distal divisions subdecussate or borne in alternating irregular whors of 3, conform, or gradually shorter, with a short, widened, abaxially subcarinate or carinate, clapping base, evenly tapering or with a short, abruptly narrowed involute cusp, 2–6 × 1.5–1.8 mm. Sporangia 1.2–1.8 mm wide.

Distribution and habitats: Endemic. Epiphytic or epilithic. Montane regions, one collection from cloud forest at 1,200 m. States of Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina, Rio Grande do Sul.
Figure 17 – a-c. Phlegmariurus linifolius var. jenmanii – a. growth habit; b. leaves of proximal division; c. sporangiate distal division. – d-f. Phlegmariurus mollicomus – d. growth habit; e. young plant; f. distal sporangiate division. – g-i. Phlegmariurus taxifolius – g. growth habit; h. leaves of proximal division; i. distal sporangiate division. (a-c. Ecuador, Napo, Río Guépi, Brandbyge & Azanza 30596 (AAU); d-f. Brazil, Mun. Petropolis, Road Fazenda Inglesa-Pati dos Alferes, Plowman & Martinelli 10128 (AAU); g-i. Peru, prope Olleras et Aipate, Humboldt (BONN-herb. Nessel)).
A somewhat heterogenous assemblage of plants, related to *Phlegmariurus heterocarpos* and apparently intermediate to members of the *P. quadrispathus* group, exhibiting strong reduction of the leaves in the squarish distal divisions, and short leaves also in the proximal divisions of the stems. *Sylvestre 1854* (RB) from Itatiaia was found together with *Phlegmariurus heterocarpos* (Sylvestre 1853, RB). Plants earlier referred to *Urostachys leitzii* are the forms resembling *Phlegmariurus heterocarpos* the most.


Plants epiphytic, erect and to ca. 20 cm tall, or recurved to pendulous, to 60 cm long, to 7 times dichotomous. Shoots homophyllous or with gradually smaller leaves in distal divisions, equally thick throughout, 20–45 mm in diam. incl. leaves, or tapering to ca. 10–20 mm upward, sporangiate in separate, seasonally produced zones from 10–30 cm above the base and upward, or continuously sporangiate in distal branches. Stems excl. leaves (1.5–)3–4(–5) mm thick at the base, upward tapering to (0.5–)1.5–3 mm, usually almost covered by the wide, bright red, decurrent leaf bases. Leaves borne in alternating whorls of 5–8, these 1–2 mm apart, forming 10–16 indistinct longitudinal ranks in proximal divisions, upward in whors of (4–)5–7, ca. 1 mm apart, spreading to reflexed, straight or upward curved, sometimes with aproximal twist and falcately upward curved, 12–25 mm long in proximal divisions, upward sometimes reduced to (7–)10–15 mm, (0.5–)0.6–0.8(–1) mm wide at the base, evenly tapering, linear to filiform, bisulcate, with prominently tumid margins and vein, the vein prominent to sunken beneath (in small juvenile individuals often only the margins somewhat tumid). Leaf bases with prominently decurrent margins and median veinal ridge, widening to ca. 1–1.5 mm below the insertion in proximal divisions, usually bright red, at least in the center and the base of the vein. Sporangia ca. 1.5–2 mm wide.

**Distribution and habitats**: Paraguay, Northern Argentina, Brazil (Ceará, Bahia, Mato Grosso do Sul, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina, Rio Grande do Sul).

Epiphytic in forests, alt. 50–1,000 m, the lower altitudes in the southern part of its range. *Phlegmariurus mandiocanus* is closely related to *P. pithyoides* (Schlecht. & Cham.) B. Øllg. (Central America, Greater Antilles and Venezuela), from which it is distinguished by its smaller dimensions.

In the protologue Raddi indicates that only one individual was found, and that this was shared with Langsdorff and Gaudichaud, who accompanied Raddi in Mandioca. (Pichi Sermolli & Pizzarri 2005). There is a Langsdorff specimen (isotype) from Mandioca in *P.*

Figure 18 – a-b. Phlegmariurus mooreanus – a. growth habit; b. distal sporangiate division. c-e. Phlegmariurus ruber – c. growth habit; d. distal vegetative division; e. distal sporangiate division. (a-b. Brazil, Bahia, Gipfel der Serra das Almas, Lützelburg 18871 (M); c-e. Brazil, Minas Gerais, Summit of Carapuça, Glaziou 15801 (P)).
Plants epiphytic, lax and pendulous to spreading, at least to 40 cm long. Shoots more or less abruptly tapering from ca. 7–20 mm in diam. incl. leaves in proximal divisions, to 1.2–3 mm in diam in distal constricted divisions, sometimes not, or only slightly tapering (juvenile or tardily sporangiate individuals), usually gradually heterophyllous, sporangiate from ca. 15–30 cm above the base and upward. Stems excl. leaves 1.5–2 mm thick at the base, tapering to 0.5–1 mm upward, prominently ridged by decurrent leaf bases, pale greenish to brownish, at least to 8 times dichotomous. Leaves usually reduced and strongly modified upward, borne in alternating whorls or irregular low spirals of 4–6 in proximal divisions, forming 8–12 indistinct longitudinal ranks, densely crowded, the whorls 1–2 mm apart, upward usually 1 mm apart. Leaves of proximal divisions spreading to ascending, usually with falcately upward curved tip, the lamina twisted to a vertical position from the base, linear, widest at the base, tapering from ca. the middle, widely joined, somewhat clasping and seemingly adnate-decurrent on the stem, softly-herbaceous to subcoriaceous, 6–12 × 0.7–1 mm, slightly concave to slightly convex adaxially, with slightly involute to revolute, smooth margins, abaxially slightly convex to slightly concave, with evident to somewhat prominent vein. Sporangiate leaves subdecussate to decussate, or borne in alternating irregular whorls of 3(–4), gradually shorter; transitional leaves lanceolate to ovate-lanceolate, with a widened, abaxially rounded, clasper base and elongate tapering slightly involute apex; sporangiate leaves of ultimate divisions strongly reduced and imbricate, clasping, rhombic-ovate to rhombic-lanceolate, usually somewhat cupulate, with a prominent vein, sometimes subcarinate, 1.5–3 × 1–1.3 mm. Sporangia ca. 1 mm wide.

Distribution and habitats: Endemic. Epiphytic in forest. Known only from the states of Bahia, Espirito Santo, and Minas Gerais. 600–1,350 m. Distinguished by the densely crowded, rather short and narrow proximal leaves and the very strongly reduced leaves of the distal, fertile divisions.


Figure 19 – a-c. *Phlegmarium recurvifolius* – a. growth habit; b. proximal vegetative division; c. distal sporangiate division. (Venezuela, Bolivar, Gran Sabana, Arautá-parú, Steyermark & Dunsterville 104163 (GB)).
Santa Lucia, 647 m, Salino et al. 8313 (BHCB, photo AAU). MINAS GERAIS: Serra do Cipó, km 149 estrada Conceição-Capão, Barreto 8560 (GH). Santa Maria do Salto, distrito de Talismã, Fazenda Duas Barras, 750–850 m, Salino 9203 (BHCB, photo AAU). Carrancas, Serra da Carrancas, Serra das Broas na Chapada dos Perdizes, 1,270–1,350 m, Salino 12282 (photo AAU).

**Phlegmariurus mollicomus** (Spring) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 17d-f


*Lycopodium sarmentosum* (Spring) B. Øllg. in size and growth habit, but differing by the more appressed, nonauriculate leaves and the prominent vein on the leaf undersides.


Plants epiphytic, pendulous, usually with flaccidly hanging divisions, to 30 cm long. Shoots homophyllous or almost so, almost equally thick throughout, 7–15 mm in diam. incl. the leaves, or gradually tapering to ca. 5 mm in diam. Stems excl. leaves 0.5–1 mm thick at the base, often tapering to 0.3 mm, prominently to sharply ridged by decurrent leaf veins, discontinuously or ultimately continuously sporangiating from 6–15 cm above the base and upward, to 6(–8) times dichotomous. Leaves borne in alternating, irregular, often oblique whors of 4–5 in proximal divisions, or of 3–4 in distal divisions, the whors 1–2 mm apart, forming 6–10 obscure longitudinal ranks, in proximal divisions ascending to patent, upward more appressed, rarely slightly twisted at the base, straight to slightly upward curved, linear to linear-subulate. Leaves of proximal sporangiations 7–11 mm long, usually loosely appressed, otherwise conform, or almost flat, with less prominent vein, often slightly widened at the base (not auriculate), rarely tinged with red on the margins near the base. Decurrent leaf bases not wider than lamina. Sporangia ca. 1 mm in diam.

Distribution and habitats: Mexico (Oaxaca), Hispaniola, Costa Rica, Panamá, Colombia, Venezuela, Ecuador, Bolivia, central and southeastern Brazil, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo and one collection labelled as from Pará (*Martius s.n.* at M). Epiphytic in lower montane forest, 800–2,400 m.

Superficially resembling the *Phlegmariurus sarmentosus* (Spring) B. Øllg. and *P. watsonianus* (Maxon) B. Øllg. in size and growth habit, but differing by the more appressed, nonauriculate leaves and the prominent vein on the leaf undersides.

**Phlegmariurus mooreanus** (Baker) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 18a,b


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Plants terrestrial, stiffly erect, to ca. 30 cm tall, to 6 times dichotomous. Shoots homophyllous, equally thick throughout, 6–10 mm in diam. incl. leaves, or tapering to 4–6 mm upward, sporangiate from ca. 10–25 cm above the stem base. Stems excl. leaves 2.5–6 mm thick at the base, sometimes tapering to ca. 1.5–2 mm upward, usually completely concealed by decurrent leaf bases. Leaves of proximal divisions borne in densely crowded, more or less regular, alternating whorls of 8–10, these 1–1.5 mm apart, forming 16–20 indistinct longitudinal ranks, uniformly strongly recurved and hook-like from an initially appressed leaf base, subulate to lanceolate, evenly tapering from the base, or protracted into a long, pale pungent apex, 4–7 × 1–1.5 mm, not twisted, prominently long-recurrent, adaxially flat or slightly convex, sometimes with slightly prominent vein, abaxially with strongly prominent vein, with pale, strongly sclerified, smooth margins. Leaves of upper, densely sporangiate divisions essentially conform, but sometimes smaller, borne in alternating whorls of 5–7, 3–4 mm long, with ovate to rhombic-ovate, not decurrent, somewhat raised leaf bases. Sporangia ca. 1.5 mm wide.

Distribution and habitats: Endemic. - Known only from the higher parts of the Serra do Sincorá and Serra Nova (Minas Gerais), in moist to marshy, exposed, rupestral vegetation. Bahia, Minas Gerais. 1,000–1,900 m.

According to a note on the holotype by Raymond M. Harley the type locality is uncertain, but probably either Andaraí, Serra do Sincorá, or Serra de Lençóis.

Reference specimens (17 collections studied): BRAZIL. BAHIA: Abaíra, Serra S of Riacho da Taquara, Harley et al. 51252a (AAU); Harley et al. 51253 (AAU). Rio de Janeiro: upper caldeira, on slopes of the Pico das Almas, ca. 25 km NNW of the town of the Rio de Contas, 1,600 m, Harley 15433 (AAU, SPF). Serra do Sincorá, 1,460 m, Mello Silva et al. 12459 (K, NY), Boom & Mori 1136 (K, NY). Pico das Almas, ca. 25 km NNW of the town of the Rio de Contas, upper caldeira, on slopes of the Pico das Almas, ca. 1,800 m, Ule 7296 (HBG). Palmeiras, Pai Inacio, BR-242, W of Lençois at 1,600 m, Harley 15433 (K, MO, NY, P, U, US). Serra do Sincorá, 1,460 m, Ule 7296 (HBG). Serras dos Lenços, Serra da Larguinha, ca. 2 km NE of Caeté-Açu (Capão Grande), Harley et al. 22600 (AAU, K); 1,400 m, Mello Silva et al. CFCR 7192 (AAU, SPF). Barra da Estiva, NW face of Serra de Ouro, ca. 9 km S of Barra da Estiva, 1,300–1,500 m, Harley et al. 20874 (AAU, K), Mucugê, Furlan et al. CFCR 441 (AAU, SPF). MINAS GERAIS: Serra Nova, Parque Nacional da Serra Nova, 1,335 m, Leite 2779 (BHCB, photo AAU).

Phlegmariurus myrsinites (Lam.) B. Øllg., Phytotaxa 57: 17. 2012. Fig. 23a,b


Lycopodium patens Willd. ex Spreng., Syst. Veg. (ed. 16) 4: 12. 1827. - Urostachys patens (Spreng.) Nessel, Bärlappgewächse 245. 1939. - Type: s.c. s.n. (B-Willd. 19342, holotype).


Published Illustrations: Smith (1981: fig. 82 a, b); Lellinger (1989: fig. 32); Mickel & Beitel (1988: fig. 3A).

Plants epiphytic, pendulous, at least to 65 cm long. Shoots heterophyllous, usually not all sharply differentiated in the basal divisions, 10–18 mm in diameter including the expanded leaves, upward gradually, within a short transition, or abruptly constricted to 1.5–3 mm thick including the reduced, imbricate leaves in the terminal divisions. Stem excluding leaves ca. 1 mm thick at the base, tapering to ca. 0.5 mm, pale greenish, to 7 times dichotomous. Expanded leaves of basal divisions decussate or subdecussate, often irregularly shaped, subdistant to densely crowded and somewhat overlapping, the leaf pairs 1.5–6 mm apart, ascending to perpendicular, ovate-lanceolate or narrowly so, acute, usually the widest ones with a rounded base, 6–11 × 1.5–3 mm, usually flat, straight to somewhat recurved, the lamina twisted to a vertical position. Leaves of terminal constricted divisions highly variable, often with complete reduction series, and with recurrent series to expanded shape, decussate or subdecussate, continuously or discontinuously
Figure 21 – a-b. Phlegmariurus sellowianus – a. growth habit; b. sporangiate division. c-e. Phlegmariurus silveirae – c. growth habit; d. leaves of proximal divisions; e. sporangiate division. (a-b. Brazil, Rio de Janeiro, Alto Macahé, Glaziou 4468 (P); c-e. Brazil, Sao Paulo, Alto da Serra, Brade 5848 (HB)).
sporangiate. Transitional leaves with widely ovate base, and short to long acuminate apex, appressed and claspig, with the wide base abaxially rounded to bluntly carinate, with straight to recurved apex, 2.5–5 × 1.5–2 mm. Shortest leaves with base conform, but with straight to falcate apex, bluntly to sharply carinate, scarcely exceeding the sporangia, ca. 2 mm long. Sporangia 1–1.3 mm wide.

Distribution and habitats: Hispanicola, S. Mexico to Costa Rica, Trinidad, Hispaniola, British Guiana, Venezuela to Bolivia, Brazilian Roraima.

Reported by Barbosa-Silva et al. (2016) from Brazilian Roraima: Serra do Aracá by Tavares 146 (not seen).

**Phlegmariurus nudus** (Nessel) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 10d,e


Plants terrestrial, ascending to erect from a decumbent base, to ca. 25 cm tall or to 50 cm long, sparsely branched, to 3–6 times dichotomous. Shoots homophyllous, equally thick throughout, 8–24 mm in diam. incl. leaves (depending on leaf direction), sporangiate from ca. 10–30 cm above the stem base, often in separate, seasonally produced zones. Stems excl. leaves 1.3–2 mm thick at the base, sometimes tapering to ca. 1.3 mm upward, pale greenish white. Leaves borne in more or less regular, often oblique, alternating whorls of 6, these 1.5–3 mm apart, forming 12 indistinct longitudinal ranks, spreading to sometimes sharply reflexed and appressed to the stem, linear, evenly tapering from the base or the middle, 6–13 × 0.6–0.8(–1) mm, not twisted at base, prominently decurrent, adaxially flat, with slightly prominent vein, abaxially with slightly prominent vein, with smooth margins. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic. Restricted to neubal forest and moist rock outcrops, moist road banks, in grasslands and river margins, alt. ca. 1,000–2,150 m in SE Brazil, in the states of Espírito Santo, Minas Gerais, Rio de Janeiro (Itatiaia, Serra dos Orgãos, Alto Macaéh), and São Paulo (Serra do Mar).

The two localities cited in the protologue are confused, the first, without collector and herbarium indication, most likely refers to the type of _Lycopodium reflexum_ var. _nudum_ Christ (= *Mayaca*, Mayacaceae). The second half of the citation applies to the lectotype. Nessel indicated Brade as collector of the type, but Brade arrived in Brazil for the first time in 1910.

Hoehne added a note to the protologue, indicating that he did not consider _Urostachys nudus_ a good species, but rather an aquatic form of _Lycopodium reflexum_ and recommended to treat it as a variety of the latter. This, however, does not invalidate the name _Urostachys nudus_, as Hoehne is not its author.

**Phlegmariurus pungentifolius** (Silveira) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 16c,d

**Figure 22** – a-c. *Phlegmarium treitubensis* – a. growth habit; b. young plant with swollen base; c. sporangiate division. d-e. *Phlegmarium regnellii* – d. growth habit of fully developed plant; e. sporangiate division. (a-c. Brazil, Minas Gerais, Mun. Baependi, São Tomé das Letras *Brade 20402* (P); d-e. Brazil, Minas Gerais, Serra de Caldas, *Mosén 4654* (S).


*Urostachys hennebergorum* Nessel, Repert. Sp. Nov. Regni Veg. 48: 169, t. 316, f. 1. 1940. - Type: Haiti, environs Bayeux, O. B. 10. Juillet 1912 (ex herb. E. Miethe, holotype BONN herb. Nessel 351). The type is probably mislabelled. No material from the Greater Antilles matches the type, which, on the other hand is indistinguishable from *Phlegmariurus pungentifolius*.

Plants terrestrial or rupestral, erect or ascending from a decumbent base, or scrambling over the ground with erect shoot apices, to 30 cm tall or to 150 cm long, at least to 10 times dichotomous, often with strongly divergent dichotomies. Shoots homophyllous, equally thick throughout or slightly tapering upward, (7–)10–20 mm in diam. incl. leaves, sporangiate from ca. 10–20 cm above the ground, often in separate periodically produced zones. Stems excl. leaves 3–4(–5) mm thick at the base, tapering to ca. 1–2 mm upward. Leaves borne in more or less regular, often oblique, alternating whorls of 6, sometimes 5 in distal divisions, sometimes 7 in proximal divisions, the whorls 1–2.5 mm apart, forming 10–14 distinct longitudinal ranks, perpendicular to reflexed, sometimes sharply reflexed, linear to linear-lanceolate, in apical, densely sporangiate divisions usually lanceolate, (4–)5–9(–15) × (0.8–)1–1.3(–1.5) mm, not twisted, adaxially flat to evenly rounded and convex, sometimes with prominent vein, rarely concave or canaliculate, abaxially with widely prominent vein, with smooth margins, finely herbaceous to coriaceous, usually lustrous above, with indistinctly and shallowly decurrent leaf bases. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic: Minas Gerais, Rio de Janeiro.

Terrestrial, grasslands and shrublands, campo rupestr, among sandstone rocks, and in rock crevices in the mountains, alt. ca. 1,200–2,000 m.

In Nessel (1927) also as *Urostachys myrtuosus* (Spring) Nessel and in 1955 as *Urostachys limbidis* nom. illeg.

Resembling *Phlegmariurus recurvifolius* (Rolleri) B. Øllg., but with shorter, more coriaceous leaves, and more divaricately branched, often quite shrub-like and scrambling over the ground. Superficially resembling *P. reflexus* (Lam.) B. Øllg., but with entire-marginated, coriaceous leaves, and a more open branching pattern.


*Phlegmariurus quadrifariatus* (Bory) B. Øllg., Rodriguésia 63(2): 481. 2012. - Fig. 9a-d


Figure 23 – a-b. Phlegmariurus myrsinites – a. growth habit, b. terminal divisions. (Venezuela, Meier & Silva 1585 (AAU)).

Published illustrations: Øllgaard 1992: p. 704, fig. 10.

Plants epiphytic, lax and pendulous, at least to 90 cm long, at least to 10 times dichotomous. Shoots narrow, usually covered by small imbricate leaves throughout, usually homophyllous or with gradually smaller leaves in distal divisions, but sometimes with long expanded leaves in short portions of the proximal divisions, sporangiate in separate, seasonally produced zones or continuously sporangiate from 10–50 cm above the base and upward. Constricted shoots incl. leaves sharply sporangiate from 10–50 cm above the base and separate, seasonally produced zones or continuously portions of the proximal divisions, sporangiate in sometimes with long expanded leaves in short gradually smaller leaves in distal divisions, but

Shoots narrow, usually covered by small imbricate to 90 cm long, at least to 10 times dichotomous. Stems excl. leaves 1.5–2 mm thick at the base, not red, tapering to 0.5–1 mm in distal divisions. Expanded leaves, if present, linear to oblanceolate, to 12 × 2–3 mm, with short-acute to obtuse or mucronulate apex, flat, with slightly revolute margins, spreading to ascending. Leaves of proximal and upper vegetative constricted divisions decussate, the leaf pairs 1–2 mm apart, usually appressed with slightly diverging apex, ovate to widely triangular-ovate, acute to acuminate, abaxially sharply carinate and conduplicate, widely and prominently long-decurrent, coriaceous, dull to lustrous, 2–3(–4) × 2–2.5(–3) mm (adding conduplicate faces), with smooth to somewhat uneven-erose margins. Sporangiate leaves often wider than long, 1.5–2 × ca. 2 mm, equalling or slightly exceeding the sporangia. Sporangia ca. 1 mm wide.


Relatively robust, differing from *Phlegmariurus fontinaloides* and *P. hexastichus* by the sharply carinate leaves throughout in the constricted, and sharply quadrangular divisions. Expanded leaves, when present, are linear-oblong, and resembling those in *P. hexastichus*.


Plants terrestrial or rupestral, erect or ascending or erect from a decumbent base, to ca. 50(–80) cm tall, sparsely branched, at least to 5 times dichotomous. Shoots homophyllous or gradually slightly reduced in distal divisions, almost equally thick throughout, ca. 13–25 mm in diam. incl. leaves or tapering to 10–15 mm, sporangiate usually from approx. 15–30 cm above the stem base and upward. Stems excl. leaves 2–4 mm thick (dried) at the base, sometimes tapering to ca. 1.5 mm upward. Leaves borne in more or less regular, often oblique, alternating whorls of (5–)6–7, these 1–2 mm apart, forming (10–)12–14 indistinct longitudinal ranks, spreading to ascending, slightly to strongly recurved from an ascending leaf base, linear to linear-lanceolate, widest just above the base, at least those of upper divisions usually terminating in a short, very thin, whip-like, yellowish or brownish, usually strongly curved or twisted tip, (5–)7–14 × (0.8–)1.2 mm, adaxially flat to somewhat concave (dried), abaxially with slightly tumid vein, usually somewhat lustrous, hypostomatic, with smooth margins. Sporangia 1.5–2 mm wide.

Distribution and habitats: Venezuela, Guyana, Brazil (Bahia, Minas Gerais, Espirito Santo). Terrestrial, erect or ascending. Open situations on sandstone mesetas, and marshy areas, 1,150–1,900 m. Information on type label: Sandstone conglomerate metamorphic & quartzitic rock
outcrops with associated scrubby vegetation with damp flushes, grass & marshes in some areas. This plant spreading between rocks on summit.

Deviates from Phlegmariurus hippurioides mainly in the softly recurving rather than sharply reflexed leaves, and by the finely protracted, twisted, pale or brownish leaf apices.

**Specimens studied:** BRAZIL. BAHIA: Serra do Sincora, among rocks, 1,200 m, Ulo 7297 (BONN herb. Nessel 220, HBG). Aitaura, Serra S of Riacho da Taquara, 1,890 m, Harley et al. 51252b (AAU). ESPIRITO SANTO: São Roque do Canaa, 1,130 m, (BHCB, photo AAU).

**Phlegmariurus reflexus** (Lam.) B. Øllg., Rodriguésia 63(2): 481. 2012. - Fig. 20a-d


clumps, 10–30(–40) cm tall. Shoots homophyllous, almost equally thick throughout, 8–14(–20) mm in diam. incl. leaves. Stems excl. leaves 1–3(–4) mm thick at base, sometimes tapering to 0.5–1.5 mm in diam., ridged by deciduous leaves or almost smooth, sporangiate from 2–10(–20) cm above the base and upward, usually 2–5 times dichotomous. Leaves borne in alternating, often irregular and oblique, whorls of 5–8(–9), these ca. 0.7–2.5 mm apart, forming 10–14(–18) longitudinal ranks, ascending to spreading or sharply reflexed, straight to strongly recurved, linear-subulate to linear-lanceolate, widest at or just above the base, (3.5–)4–8 × 0.5–1(–1.2) mm, softly herbaceous to subcoriaceous, adaxially convex and usually somewhat lustrous, or concave near the base, abaxially flat, or slightly concave to convex, with obscure to widely prominent vein, with flat to revolute, very sparsely to densely denticulate to short-ciliolate margins. Leaf bases often somewhat decurrent. Sporangia 1–1.5 mm in diam.

Distribution and habitats: Throughout humid mountainous regions of tropical America, south to northern Argentina. Land slides, road banks, and other open or disturbed habitats in montane forest, alt. 300–2,300 m.


As testified by the number of synonyms this is a variable species, or rather a species aggregate. In earlier treatments (Øllgaard 1988, 1994, 1995, 2012a) *Phlegmariurus reflexus* var. minor (Spring) B. Ollg. was recognized on the basis of size mainly. However, during the present revision it was found that this criterion was insufficient to maintain such a taxon.


Phlegmariurus regnellii (Maxon) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 22d,e


Published illustrations: Maxon, 1914; t. 23.

Plants terrestrial or rupestral, erect or ascending from a decumbent base, to ca. 30 cm tall, at least to 6 times dichotomous. Shoots homophyllous or with gradually shorter leaves upward, equally thick throughout or tapering, ca. 15–20 mm in diam. incl. leaves, usually tapering to 5–10 mm, sporangiate from ca. 10–20 cm above the ground. Stems excl. leaves 3–5 mm thick at the base, tapering to ca. 1–2 mm upward. Leaves of proximal divisions borne in more or less regular, often oblique, alternating whorls of 6–7, these 1–3 mm apart, in distal divisions in whorls of 5–6, ca. 1 mm apart, forming 10–14 indistinct longitudinal ranks, perpendicular to ascending, upward sometimes closely appressed, linear to linear-lanceolate, in apical, densely sporangiate divisions usually lanceolate, (4)–5–9(–15) × 1–1.3(–1.5) mm, not twisted, adaxially flat to slightly concave, usually with prominent vein, abaxially flat to distinctly convex, with flat to slightly revolute margins and widely prominent vein, with smooth margins, firmly herbaceous to coriaceous, usually lustrous, with shallowly decurrent leaf bases. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic. The information about the ecology of this species is limited. There are few collections. Forest margins, among rocks, 1,000–1,835 m. Minas Gerais, Rio de Janeiro.

Phlegmariurus regnellii is related to P. pungentifolius, but differs in the stiffly erect growth habit, and the reduced and ascending to appressed leaves in the distal divisions. This seems a different reaction to exposed conditions than the reflexed leaves in P. pungentifolius under similar conditions. Personal observation by Ashley Field (CNS, BRI): “Phlegmariurus regnellii grows in humus pockets in crevices or out in the open on the massive rocky outcrop of Pedra Branca, it is softer than P. pungentifolius. By contrast P. pungentifolius (I did not see the two anywhere near each other) I found grew more in grasslands and shrublands like Campo Rupestre“. The cited specimen: Serra dos Orgãos, Glaziou s.n. (RB) is probably mislabelled, like several other Glaziou specimens.

Specimens studied: BRAZIL. MINAS GERAIS: Serra de Caldas, 1,000 m, Mosén 4654 (P, S); Mosén 2015 (BONN-Nessel 54, S). Carangola, Alto da Serra da Grama, 1,835 m, Kuhlmann 37 (RB). Caldas, distrito de Pocinhos do Rio Verde, Pedra Branca, 1,650 m, Salino 12646 (BHCN, photo AAU). RIO DE JANEIRO: Serra dos Orgãos, Glaziou (RB) probably a wrong locality.

Phlegmariurus rostrifolius (Silveira) B. Øllg., Rodriguésia 63(2): 481. 2012. Fig. 7c,d


Plants terrestrial, erect or ascending from a decumbent base, soft, usually forming small loose clumps, to ca. 10 cm tall. Shoots homophyllous, almost equally thick throughout, ca. 6–7 mm in diam. incl. leaves. Stems excl. leaves 1.5–2 mm thick, densely covered by leaves, sporangiate from ca. 5 cm above the base and upward, to 4 times dichotomous. Leaves borne in alternating, irregular whorls of 5–6, these ca. 1–1.5 mm apart, forming 10–12 longitudinal ranks, loosely appressed to ascending, upward curved especially at the apex, subulate at the base, to linear-lanceolate in apical divisions, widest just above the base, 3–5 × ca. 1 mm, subcoriaceous, adaxially concave with...
Phlegmariurus ruber (Cham. & Schltdl.) B. Øllg., Rodriguésia 63(2): 481. 2012. - Fig. 18c–e
Published illustrations: Øllgaard 1992: Fig. 5.

Plants terrestrial, stiffly erect, often from an ascending base, forming dense clumps, to ca. 30 cm tall, at least to 3 times dichotomous. Shoots bright red, gradually heterophyllous, with shorter leaves upward, tapering and with fewer leaf ranks upward, 6–10 mm in diam. incl. leaves at the base, tapering to (3–)4–6 mm, sporangiate from ca. 10–20 cm above the base and upward. Stem excl. leaves 3–5 mm thick at the base, upward tapering to ca. 1 mm, completely concealed by leaves. Leaves of proximal divisions densely crowded and closely imbricate, borne in alternating whorls of 4–5, these 1.5–2 mm apart, forming 8–10 longitudinal ranks, straight, or with slightly curved or twisted apices, linear to linear-lanceolate, evenly tapering from the base, 9–12 × 1.5–2 mm, bluntly carinate to almost conduplicate, bright dark red, with smooth margins. Leaves of upper, densely sporangiate divisions borne in alternating whorls of 3–4, these 1–1.5 mm apart, forming 6–8 regular longitudinal ranks, lanceolate to widely ovate, acuminate to long-cuspidate (due to conduplicate apex), with sharply carinate apex, or carinate throughout, (3–)3.5–7 × 1.5–2.5 mm, coriaceous, with smooth margins. Sporangia ca. 2 mm wide.

Distribution and habitats: Endemic. Summits of higher mountains of the Iron Quadrangle in Minas Gerais State, with recent records only in the region of Serra do Caraça. Two Glaziou specimens from Bahia and Rio de Janeiro are probably mislabelled. On rocks and in rock crevices, occurring apparently only at alt. 1,300–2,060 m.

Another highly distinctive high-altitude species. Readily identified by its deep red stems and leaves.


Phlegmariurus sellowianus (Herter) B. Øllg., Rodriguésia 63(2): 481. 2012. - Fig. 21a,b

Plants epiphytic or terrestrial, erect from a hanging or decumbent base, at least to 40 cm tall, or to 70 cm long, sparsely branched, to 3(–4) times dichotomous, often with lax and flexuous stems. Shoots homophyllous, almost equally thick throughout, 20–30 mm in diam. incl. leaves. Stems excl. leaves 2–4 mm thick near the base, 1–3 mm in upper divisions, somewhat ridged by
decurrent leaf bases, sporangiate from 5–30 cm above the base and upward. Leaves almost uniform throughout, borne in alternating, often oblique whorls of 3–4, these 1.5–4 mm apart, forming 6–8 indistinct longitudinal ranks, perpendicular-spreading to somewhat reflexed, usually straight, sometimes slightly recurved, not twisted at the base, lanceolate, with long-acute apex, papery to subcoriaceous, (10–)13–20 × 2.5–3.5 mm, almost flat, with prominent vein above, or folded slightly down along the vein, with slightly revolute, smooth to minutely rugose by individually protruding margin cells. Sporangia ca. 2 mm in diam.

Distribution and habitats: Endemic. Terrestrial or epiphytic in forest, alt. (200–)700–2,000 m, the lower altitudes in the southern part of the range. Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina.

Phlegmariurus sellowianus is related to P. brongniartii (Spring) B. Øllg. from the Andes, and often has been classified as that species. However, differences of phyllotaxis and a more lax, decumbent to ascending growth habit separates this species from the latter species.


Plants epiphytic or rupestral, lax and pendulous to spreading, sometimes recurved from an erect and somewhat rigid stem base, to 40 cm long. Shoots almost equally thick throughout or gradually tapering, ca. 20–30 mm in diam. incl. leaves at the base, sometimes tapering to (5–)7–15 mm in diam. in distal, densely sporangiate divisions of fully developed plants, sporangiate from 10–25 cm above the base and upward, rarely abruptly constricted. Stems excl. leaves 1.5–2 mm thick at the base, tapering to 0.5–1.5 mm upward, prominently ridged by decurrent leaf bases, pale greenish to brownish, usually 3–6(–8) times dichotomous. Leaves borne in alternating whorls or irregular low spirals of 3 or 4, these 1.5–4 mm apart, forming 6–8 indistinct longitudinal ranks, or leaves of distal divisions sometimes indistinctly decussate. Leaves of proximal divisions spreading to somewhat reflexed, rarely ascending, often twisting the lamina to a vertical position from the base, lanceolate to linear-lanceolate, widest from the lower half to the middle, rather narrowly joined to the stem, not clasping, somewhat adnate-decurrent on the stem, with prominently long-decurrent leaf base margins and vein, soft herbaceous to subcoriaceous, 11–20 × 1.2–3 mm, almost flat or somewhat convex adaxially, with flat to strongly revolute, smooth margins, adaxially...
with prominent vein, with evident to somewhat prominent vein abaxially. Leaves of middle and distal divisions spreading, usually conform but often gradually shorter and narrower, rarely more appressed and abaxially more convex. Leaves of fully sporangiate divisions usually spreading, rarely ascending to slightly appressed, often with slightlywidened, somewhat clasping, abaxially convex base, not covering the sporangia, 5–12(–17) × 1.2–2 mm. Sporangia 1.5–2 mm wide.

Distribution and habitats: Endemic. Epiphyte, or occasionally rupestral in high altitude montane forest, 800–2,400 m alt., in the states of Minas Gerais, Paraná, Rio de Janeiro, Santa Catarina, and São Paulo.

With rather wide, and flattened, strongly twisted leaves, approaching Phlegmariurus taxifolius (Sw.) A.Löve & D.Löve.

In the protologue of Urostachys silveirae Nessel refers to the text and illustration of Lycopodium martii in Silveira (Bol. Comm. Geogr. Geol. Minas Gerais (2) 5: 142, t. 5, 1898), and probably meant to base his new species on Silveira’s new material. The plate in Silveira (l. c.) illustrates a plant belonging to this taxon.


Phlegmariurus taxifolius (Sw.) A.Löve & D.Löve, Taxon 26: 324 (1977).

Lycopodium taxifolium Sw., Prodomus 138. 1788.


Plants epiphytic, lax and pendulous, or sometimes recurved from an erect and somewhat rigid stem base, to 50(−80) cm long. Shoots usually gradually tapering from ca. 15–30 mm in diam. incl. leaves at the base, to 5–15 mm in diam. in distal, densely sporangiate divisions of fully developed plants, sporangiate from 20–50 cm above the base and upward, sometimes not, or only slightly tapering (juvenile or tardily sporangiate individuals), rarely abruptly constricted. Stems excl. leaves 1.5–2.5 mm thick at the base, tapering to 1–1.5 mm upward, somewhat ridged by decurrent leaf bases, pale greenish to brownish, usually to 6 times dichotomous. Leaves usually reduced and modified upward, borne in alternating whorls or irregular low spirals of 3 or 4, these 1.5–4 mm apart, forming 6–8 indistinct longitudinal ranks. Leaves of proximal divisions spreading to ascending or somewhat appressed, often twisting the lamina to a vertical position from the base, narrowly lanceolate, widest in the lower half, widely joined to the stem, firmly herbaceous to subcoriaceous, 11–18 × 1.5–2 mm, almost flat or somewhat concave adaxially, with flat or slightly revolute, smooth margins, with evident to somewhat prominent vein abaxially. Leaves of middle and distal divisions usually gradually shorter, narrower and more appressed, abaxially more convex, often with involute margins. Leaves of fully sporangiate divisions often distinctly 6-ranked, rarely decussate, with strongly widened, clasping base, partly covering the sporangia, often abruptly contracted into a short to long, narrow, involute apex, (3−)5–12 × 1–1.5 mm. Sporangia ca. 1.5 mm wide.

Distribution and habitats: Central America, West Indies, northern South America, south to Peru and in Brazil in coastal forest, alt. 0–1.050 m, in the West Indies, northern South America, south to Peru and in Brazil in coastal forest, alt. 0–1.050 m, in the states of Amapá, Amazonas, Ceará, Rio de Janeiro, and São Paulo, and Paraná.

A variable species of problematic delimitation. Individuals which are morphologically intermediate between Phlegmariurus taxifolius and P. silveirae are frequent.


Plants terrestrial, stiffly erect, to 30 cm tall, to 4(−5) times dichotomous. Shoots homophyllous, or with gradually shorter leaves upward, (12−)15–20 mm in diam. incl. leaves at the base, usually tapering to 8–12 mm upward, sporangiate from ca. 10 cm above the base and upward. Stem excl. leaves 5–7 mm thick at the base, upward tapering to ca. 2–3 mm, completely concealed by leaves. Leaves of proximal divisions densely crowded and closely appressed, at the very stem base often aggregated to a thickened somewhat bulb-like shoot base, borne in alternating whorls of ca. 8–10, these ca. 1 mm apart, forming ca. 16–20 indistinct longitudinal ranks, straight, linear-subulate to linear-lanceolate, evenly tapering, 12–16 × 1–1.3 mm, adaxially usually concave (rarely convex) with distinctly prominent vein, abaxially flat to slightly convex, with widely prominent or sunken (dried) vein, subcoriaceous, dull to lustrous, with smooth
Margins. Leaves of upper, densely sporangiate divisions borne in alternating whorls of 5–8, these ca. 1 mm apart, forming 10–16 longitudinal ranks, linear-lanceolate to lanceolate, 5–9 × 1–1.5 mm, otherwise conform. Sporangia ca. 2 mm wide.

Distribution and habitats: Endemic. Restricted to few high mountains, in open rupestral habitats on sandy soil. Minas Gerais, 1,300–1,900 m.

Leaves of proximal divisions densely crowded, closely appressed, at the stem base often aggregated to a thickened bulblike shoot base.


Fig. 14e,f


Published illustrations: Lellinger, 1989: fig. 44; Mickel & Beitel, 1988: fig. 4B; Øllgaard, 1988: p. 17 fig. 1C.

Plants epiphytic, or occasionally terrestrial, erect, arculate-spreading to pendulous, to 20(–30) cm long. Shoots homophyllous, 1.5–2.5(–3) cm in diam. incl. leaves, equally thick throughout, or in some slender individuals gradually tapering to 1–1.5 cm in distal divisions. Stems excl. leaves (1–)1.5–2(–3) mm thick at the base, often tapering to (0.7–)1 mm, prominently ridged by decurrent leaf bases, pale green to stramineous, often with bright red spots on leaf bases, sporangiate, often in seasonally produced zones, from 5–15 cm above the base and upward, 3–6(–9) times dichotomous. Leaves usually uniform throughout, borne in alternating, often irregularly oblique whorls of 6–7, these 0.5–1.5 mm apart, in proximal divisions, upward often in whorls of 4–5, forming 8–14 indistinct longitudinal ranks, perpendicularly spreading to ascending, straight to upward curved, usually not twisted at the base, linear to filiform, (6–)10–17 × 0.3–0.5 mm, quickly narrowed to ca. 0.2 mm wide due to involution, gradually tapering toward the tip, adaxially canaliculate to involute, often with a prominent vein abaxially near the base. Leaves of distal divisions in old plants sometimes gradually reduced to 6(–4) mm long. Decurrent leaf bases usually not wider than the lamina base, often bright red. Sporangia 1–1.5 mm in diam.

Distribution and habitats: Mexico (Oaxaca) to Panama, West Indies, northern South America south to Bolivia, Brazil: Mato Grosso. Wet mid-altitude forests.

**Phlegmariurus wilsonii** is related to *P. dichotomus*, *P. pithyoides* and *P. mandiocanus*. With these it shares the bottle-brush-like growth habit, and with the latter two the bright red coloration of the leaf bases. Pendulous individuals of *P. wilsonii* are rather similar to *P. polycarpos* (Kunze) B. Øllg. (Costa Rica, Panamá, Colombia to Bolivia), which is very slender and has shorter, more flattened, leaves, and uniformly falcate leaves due to a basal twist, and is apparently always pendulous.
The absence or presence of red colour on the leaf bases seems not to be correlated with other characters, and the intensity and size of the coloration is variable. The direction of leaves is correlated with growth habit. In erect-growing plants the leaves are wide-spreading to almost reflexed, whilst in pendulous plants the leaves are somewhat ascending.

Usually an erect epiphyte, but sometimes becoming pendulous when very large. Only one Brazilian collection studied.

Note: According to the protolog the type of Lycopodium wilsonii is Wilson 271, but Wilson 153 (NY) is annotated by the author as sp. nov. and fits the description best, while Wilson 271 (NY) is Phlegmariurus dichotomous and is not annotated as sp. nov.


Acknowledgements
This project would not have been possible without the generous collaboration of several herbaria, who provided large loans of Brazilian material: AAU, B, BHCB, BM, BONN, BR, C, CESJ, E, F, FLOR, GH, GUA, HB, HBG, HBR, HRCB, ICN, K, L, M, MBM, MG, MO, NY, P, PACA, PAMG, R, RB, S, SI, SJRP, SP, SPF, U, UB, UC, UNB, US, W.

Numerous excellent photographs of specimens were provided by Vinicius Antonio de Oliveira Ditrich (CESJ), Alexandre Salino (BHCB), and Fernando Matos (NY). They added important data on distribution and morphological variation. Illustrations were made by K. Tind (Figs. 1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17a-f, 18, 19, 20, 21, 22) and B. Johnsen (Figs. 6, 14, 17g-i).

The first author is grateful to the staff of the herbarium of the Botanical Garden in Rio de Janeiro, especially Lana Sylvestre and Claudine Mynssen for their help during his stay there, and to the staff of the Botanical Museum of Rio de Janeiro for help during my visit. We are grateful to Thais Almeida for Ashley Field for very useful suggestions for the manuscript, and for sharing their important field observations of these plants with us.

The working facilities and generous assistance, particularly by Finn Borchenius and Birgitte Bergmann, for this project in Herbarium AAU of the institute of Bioscience, and the Science Museums of Aarhus University are gratefully acknowledged.

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stelar morphology, the shoot apex and gemmae of *Lycopodium lucidulum* Michaux (Lycopodiaceae).