Re-establishment of *Drosera spiralis* (Droseraceae), and a new circumscription of *D. graminifolia*

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Abstract

*Drosera graminifolia* and *D. spiralis* have long been considered conspecific, but new morphological and ecological data support the recognition of these taxa as distinct species. Both species are here described and illustrated, including observations on ecology, habitat, and conservation status, together with a distribution map, line drawings, photographs, and a table containing the distinctive characters.

Resumo

*Drosera graminifolia* e *D. spiralis* foram por muito tempo consideradas co-específicas, mas novos dados morfológicos e ecológicos mostraram que as espécies são bastante distintas. Ambas as espécies são aqui descritas e ilustradas, incluindo observações sobre ecologia, habitat e status de conservação, junto com um mapa de distribuição, ilustrações, fotografias e uma tabela com as características distintivas.

Key words: Cadeia do Espinhaço, carnivorous plants, ecology, IUCN Red List, Minas Gerais, morphology, sister species

Introduction

The genus *Drosera* Linnaeus (1753: 281) was first thoroughly studied in Brazil by the French naturalist Auguste de Saint-Hilaire (1824, 1826), who traveled the country in the early 19th century, and later published several new *Drosera* taxa, including two that were characterized by their long, grass-like leaves: *D. graminifolia* Saint-Hilaire (1826: 269), based on material collected at the Serra do Caraça, and *D. spiralis* Saint-Hilaire (1826: 270), based on material collected at the Serra de Curumathay (currently Curimataí), northwest of the town of Diamantina, both in Minas Gerais state, southeastern Brazil.

Eichler (1872), in Martius’ *Flora Brasiliensis*, added a new taxon to this complex: *D. graminifolia* var. *major* Eichler (1872: 396), based on material collected by the German plant collector Friedrich Sellow at the Serra do Caraça. Also, based on the manuscripts and material studied by Martius, Eichler included *D. brasiliensis* Martius ex Eichler (1872: 396) under synonymy of *D. graminifolia*.

Diels (1906), in his generic revision, included *D. spiralis, D. brasiliensis* and *D. graminifolia* var. *major* as synonyms under *D. graminifolia*, and his taxonomic opinion has been strictly followed in all subsequent floristic and taxonomic treatments (including Silva 1994, Silva & Giulietti 1998, Correa & Silva 2005, Silva 2012).
Following our study of both wild populations and cultivated plants, as well as of the holotypes and numerous other herbarium specimens, a revision of the *D. graminifolia* complex is here deemed necessary. Our data all reinforce the existence of significant differences between plants from the Serra do Caraça, corresponding to *D. graminifolia*, and plants found further north along the Serra do Espinhaço highlands, corresponding to *D. spiralis*.

**FIGURE 1.** Distribution of *D. graminifolia* (square) and *D. spiralis* (circles).
Material and methods

Extensive field studies were undertaken by the authors between 1990 and 2011 across the known natural range of populations of *D. graminifolia s.l.* from the Serra do Caraça to the Serra de Grão Mogol in central to northern Minas Gerais state, southeastern Brazil. In addition, herbarium specimens at BHCB, HB, MBM, OUPR, R, RB, SP, SPF, and UEC were personally examined under stereo dissecting microscope and annotated by at least one of the authors. Type material held at P was personally examined by F.Rivadavia, and high resolution images of the type material held at P and B was also examined by the authors (Röpert 2000—continuously updated; Anonymous 2012–continuously updated). Herbarium acronyms follow *Index Herbariorum* (http://sweetgum.nybg.org/ih/). Descriptions were based on fresh, dried and spirit material.

The distribution map was prepared using georeferenced location data obtained from herbarium records (extrapolated or approximated for a few old or vaguely specified localities) and our own field observations.

Taxonomic treatment

**Drosera graminifolia** Saint-Hilaire (1826: 269). Figs. 2, 3.

Type:—BRAZIL. Minas Gerais: “Crescit in summis montibus dictis Serra-da-Caraça; alt. circiter 6000 ped. Florebat Februario”, *Saint-Hilaire s.n.* (holo P!).

**Drosera graminifolia** var. *major* Eichler (1872: 396). Type:—BRAZIL. Minas Gerais: Serra do Caraça, December 1830, *Sellow 1300* (holo B image!).

Illustrations:—Saint-Hilaire (1826: t. XXV); Diels (1906: 87, fig. 31M, N).

Perennial rosetted herbs, acaulescent or forming short stems up to 6(–15) cm long, covered by the persistent dead leaves. General indumentum consists of white eglandular hairs 1.5–3.5 mm long (longest on leaves), translucent-yellow short-stalked multicellular globose (“TSG”) trichomes 0.1–0.12 mm in diameter, and sessile glands 0.03 mm in diameter. Leaves 110–240(–295) mm long, linear, with regular circinate vernation, green in color, erect to semi-erect, patent when old, apex narrowly acute, ending in a single tentacle; petioles 30–45(–50) mm long, 1.5–2.4 mm wide, abaxial and adaxial surfaces covered with TSG trichomes, sessile glands and eglandular hairs, hairs sparser on the adaxial surface (relative to abaxial surface), very narrowly transversely elliptic (flat) in cross section; lamina 80–195(–245) mm long, 1.2–3(–3.5) mm wide, adaxial surface covered with numerous translucent red, carnivorous, capititate tentacles, sessile glands and TSG trichomes, abaxial surface covered with eglandular hairs, sessile glands, and TSG trichomes; stipules 7–14 mm long, 6.5–10 mm wide at the base, triangular, membranaceous, bronze-gold in color, apex acute and fimbriate. Scapes 1–2 per plant, (180–)240–380 mm long (including inflorescence), 1.5–3 mm in diameter at the base, base erect; inflorescence a scoriroid cyme, often bifurcate, bearing 9–23(–35) flowers, indumentum of the scape, pedicels, abaxial surfaces of bracts and sepals consisting of eglandular hairs, sessile glands, and TSG trichomes; bracts 2–5.5 mm long, lanceolate, usually absent; pedicels 2–7.5 mm long, inserted 3–15 mm apart from each other; sepals 5, 6.5–9.5 mm long, 1.8–2.3(–3.5) mm wide, oblong-lanceolate to oblong-oblanceolate, united at basal 1/4–1/5 of length; petals 5, 7–10 mm long, 4–7 mm wide, obovate, light pink-lilac in color; stamens 5, 3.5–4.5 mm long, anthers 1–1.3 mm long, bithecate, yellow; ovary 1.3–1.6 mm in diameter at anthesis, 3-carpellate, globose to globose-ellipsoid, slightly 3-lobed in outline; styles 3, forked at the base, 3.5–4.5 mm long (including stigmata), stigmata flabellate or bilobed, pink-lilac in color. Fruit a dry capsule, 3–3.5 mm long, ellipsoid, 3-valvate. Seeds oblong-fusiform, 0.65–0.8 mm long, c. 0.2 mm wide, testa reticulate, black.
**FIGURE 3.** *Drosera graminifolia* at Serra do Caraça, central Minas Gerais state. **A,** high-montane habitat with open shrubby vegetation. **B,** habit. **C,** base of a rosette, showing the short stipules and long petioles. **D,** young leaf showing the regular circinate vernation. **E,** flower (A–D by P.M. Gonella; E by Leonardo Desordi, used with permission).
**Distribution and ecology:**—Brazil, Minas Gerais, southern Cadeia do Espinhaço highlands, endemic to the Serra do Caraça, between the municipalities of Catas Altas and Santa Bárbara (Fig. 1). *Drosera graminifolia* is also doubtfully reported from the Serra do Gandarela (Serra do Retiro) by a single specimen from the 19th century (*Damazio s.n.*, s.d. (OPUR 4308)), mislabeled Serra do Betim by Silva (1994), Silva & Giulietti (1997), and Correa & Silva (2005).

*Drosera graminifolia* grows in vegetation intermediate between *campo rupestre* and *campo de altitude*, in very narrow habitats mostly defined by altitude, in high-montane regions at elevations of (1700–)1800–1950 m. It forms small and scattered populations at the Serra do Caraça near the summits of the four highest peaks (Canjerana, Carapuça, Inficcionado, and Sol), growing in a peat-sand soil mixture, or on a thin layer of this same soil over sandstone, or more rarely in cracks of bare sandstone, commonly among mosses such as *Sphagnum* L. spp. (Sphagnaceae) and often partially shaded by short shrubs (Fig. 3A).

*Drosera graminifolia* has been observed to grow vigorously the whole year round. Even during the dry season its habitat does not dry out completely, due to the regular water condensation that occurs at night on the mountain summits, keeping the soil constantly moist just under the surface. This species grows sympatrically with *Genlisea violacea* Saint-Hilaire (1833: 431), *Utricularia laciniata* Saint-Hilaire & Girard (1838: 870), *U. reniformis* Saint-Hilaire (1830: 224), and *U. subulata* Linnaeus (1753: 18), of the Lentibulariaceae family, all of which are also carnivorous.

**Phenology:**—*Drosera graminifolia* flowers early in the wet season, from January to April. A secondary and minor flowering period between August and September was reported by Rivadavia (1996).

**Conservation Status:**—The Serra do Caraça is located in the Quadrilátero Ferrífero (‘Iron Quadrangle’), a region that bears a unique flora but has long suffered from intense mining of its rich mineral deposits. Unfortunately, mining has resulted in the recent degradation of several localities of native vegetation in this region, including preserved areas such as the Serra do Caraça (SC). As a direct consequence of intense mining activities at the eastern and southern base of the SC, just outside the park, a significant decrease in population size of *D. graminifolia* was observed during the 1990’s, reduced to a single adult plant on Mt. Carapuça in 2000 (F. Rivadavia, pers. obs.). During this period, the fragile and unique flora native to the SC highlands deteriorated, possibly due to particulate matter pollution from the adjacent mining activities, leading to increased accumulation of dead vegetation—which in turn fueled a large fire in September of 1997. This fire was reported as the main cause of local extinction of the Lycopodiaceae *Huperzia rubra* (Chamisso & Schlechtendal 1833: 389) Rothmaler (1944: 60), as well as many other species at the SC massif, and was the facilitator for the invasion of the highland areas by exotic grasses that compete with the local species for light and space (Vasconcelos et al. 2002), and also increase the flammability of the *campo rupestre* vegetation (Alves & da Silva 2011).

Fortunately, the highland vegetation of the SC has made a surprising recovery over the past decade— including *D. graminifolia*, which seems to have recolonized most of the areas where it was observed to grow in the early 1990’s, before its near extinction at the turn of the millennium. However, it is hard to estimate if and how many other species suffered extinction at the SC as a result of this tragic incident, and how many other species are indirectly doomed to extinction due to a population crash (and inescapable genetic bottleneck) similar to that suffered by *D. graminifolia*.

According to the criteria of the IUCN Red List (2001), *D. graminifolia* is considered as Critically Endangered (CR) due to the small and isolated populations of this species, its restricted distribution area, the drastic reduction of population size over the past 20 years, and the possible continuous decline in quality of the habitat caused by further side effects of mining, including the increase of invasive species of grasses, especially *Melinis minutiflora* Palisot de Beauvois (1812: 54), regionally known as *capim gordura*.

**Notes:**—The type of *D. graminifolia* var. major was examined and clearly represents only a robust individual of *D. graminifolia*. The characteristics cited by Eichler (1872)—longer leaves (over 20 cm in length), plus denser and longer indumentum on leaves and scapes—are within the range of variation reported here for *D. graminifolia*. 

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As the type specimen of *D. graminifolia* var. major is only numbered as "1300" on a small separate handwritten sheet, but no lowercase letter in front of the number, this collection must have been made on Sellow’s 6th (and last) Brazilian journey, when he travelled from eastern São Paulo state to Minas Gerais state between 1829 and 1830 (Urban 1893). Sellow made c. 1500 collections on this trip, thus specimen 1300 must have been collected towards the end. According to Urban (1893), Sellow was not able to continue to northern Minas Gerais and further west to Goiás state as was the plan for the end of that expedition. Therefore, he went on to Ouro Preto in November 1830, from where he made various smaller expeditions to Itacolomi (currently Itacolomi) and, in the second half of December 1830, to the Serra do Caraça (where we suspect the last collections were made, with numbers up to c. 1500). This *D. graminifolia* specimen must have been one of Sellow’s very last collections, as he returned to São Paulo state in early 1831, where he made his testament in March 1831, and died only shortly after (at the age of 42) when swimming in the Rio Doce (Urban 1893).

The name *D. brasiliensis* was first cited by Martius in his hand-written field notes and later considered by Eichler (1872) as a synonym of *D. graminifolia*. Since the name was not effectively published by Martius, but cited and considered only as a synonym by Eichler (1872), the name must be considered invalid according to Art. 34.1. of the ICBN (McNeill et al. 2006), which states that “a name is not validly published […] (c) when it is merely cited as a synonym; […]”.

The specimen *Martius 1287* (voucher for *D. brasiliensis*) unfortunately could not be found at neither M nor BR (where specimens from Martius are held). It was allegedly lent to Diels at B for his treatment of Droseraceae for the Pflanzenreich, and was probably destroyed during World War II. However, taking into consideration the location data cited by Eichler—“Inter Cidade Diamantina et Bandeirinha” (Bandeirinha is a district of the city of Diamantina)—this specimen would best fit as conspecific with *D. spiralis*, because it lies within the geographic range of this species.

Line drawings of *D. graminifolia* in Eichler (1872), Silva (1994), Silva & Giulietti (1997), and Correa & Silva (2005) illustrate *D. spiralis* instead. The latter three publications also refer to the adaxial surface of the sepals as being ciliate, but this character was not observed in any of the specimens examined of either *D. spiralis* or *D. graminifolia*.


**Drosera spiralis** Saint-Hilaire (1826: 270). Figs. 4, 5.

Type:—BRAZIL. Minas Gerais: “Crescit in montibus dictis Serra de Curumatahy, ad rivulum Corgo Novo, in parte provinciae Minas Geraes dicta Distrito dos Diamantes; alt. circiter 3700. Inveni Septembre cum fructibus”, *Saint-Hilaire s.n.* (holo P!).

*Drosera brasiliensis* Martius ex Eichler (1872: 396), nom. inval., syn. nov.

Illustrations:—Eichler [1872: t. 91, II (as *D. graminifolia*)]; Silva [1994: 51, fig. 9 (as *D. graminifolia*)]; Silva & Giulietti [1997: 86, fig. 6 (as *D. graminifolia*)]; Correa & Silva [2005: 40, fig. 24A–E (as *D. graminifolia*)].
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Perennial rosetted herbs, acaulescent or forming short stems up to 10 cm long, covered by persistent dead leaves. General indumentum consists of white eglandular hairs 0.5–1.5 mm long, minute sessile glands c. 0.03 mm in diameter, and glandular capitate trichomes 0.1–0.5 mm long (each of these often bearing a dried droplet of a translucent-yellow secretion in herbarium specimens). Leaves 75–350 mm long, with irregular circinate vernation, erect to semi-erect, patent when old, linear, spirally twisted when dead, apex aciculate, ending in a single tentacle; petioles 5–30 mm long, 1–3 mm wide, green in color, glandular pilose on both surfaces, abaxially only along the margins and adaxially absent near the very base, sparse eglandular hairs along the margins, semicircular to transversely elliptic in cross section; lamina 70–320 mm long, 0.6–2.8 mm wide, green, yellowish-green or reddish-green in color (especially towards the apex), adaxial surface covered with numerous red, carnivorous, capitate tentacles, abaxial surface densely glandular and eglandular pilose; stipules 14–22(–30) mm long, 8–22 mm wide at the base, triangular, membranaceous, patent when old, bronze-gold in color, apex acute, fimbriate or entire. Scapes 1–2 per plant, 110–430 mm long (including inflorescences), 0.6–3 mm in diameter at the base, base erect; inflorescence a scorpionid cyme, often bifurcate to multiply branched (up to 8 times), occasionally with 1–3 larger sterile bracts at the base, bearing 5–78(–90) somewhat congested flowers, indumentum of the scape, pedicels, abaxial surfaces of bracts and sepals consisting of eglandular hairs, glandular capitate trichomes, and sessile glands; bracts 2.5–4 mm long, lanceolate, usually absent; pedicels 1–7.5 mm long, inserted 1.5–7 mm apart from each other; sepals 5, 4.5–7.5 mm long, 1.5–2.2 mm wide, oblanceolate to lanceolate, united at basal 1/3–1/4 of length, often bearing 1–several emergences similar to the tentacles found on the lamina; petals 5, 6–10 mm long, 5.7–5.7 mm wide, obvate to obovate-cuneate, light to dark pink-lilac in color, rarely white; stamens 5, 4–6 mm long, anthers 1–1.6 mm long, bicate, yellow; ovary 3-carpellate, 1–1.5 mm in diameter at anthesis, globose, slightly 3-lobed in outline; styles 3, forked at the base to 1/3 of length, 3–4.5 mm long (including stigmata), stigmata flabellate, pink-lilac in color. Fruit a dry capsule, c. 3 mm long, ellipsoid, 3-valvate. Seeds ovoid, 0.6–0.65 mm long, 0.25–0.3 mm wide, testa reticulate, black.

Distribution and ecology:—Brazil, endemic to the central and northern parts of the Serra do Espinhaço, in Minas Gerais state. *Drosera spiralis* has a disjunct distribution, occurring on the Diamantina Plateau in the municipalities of Diamantina, Serro, Couto de Magalhães de Minas, Rio Vermelho, São Gonçalo do Rio Preto, Buenópolis, and—after a gap of approximately 100 km—in the municipalities of Itacambira, Botumirim, and Grão Mogol (Fig. 1).

*Drosera spiralis* is common in campo rupestre vegetation of montane regions at elevations between 700 and 1500 m. It is very resistant to soil desiccation, often growing in exposed habitats that become parched during the winter dry season. On the Diamantina Plateau, *D. spiralis* is usually found in small and scattered populations along seasonal streams and seepages, in sandy soils mixed with peat, or in cracks of quartzitic sandstone, at elevations between 800 and 1500 m. At the Northern Mountains Complex, *D. spiralis* commonly forms larger populations in the same habitats and also in perennial boggy seepages (Fig. 5A), or more rarely along the margins of perennial rivers over quartzitic sandstone (Fig. 5C) at elevations between 700 and 1350 m.

Healthy *D. spiralis* plants are often found in full bloom at the height of the dry season, suggesting that they are quite capable of avoiding desiccation in water-stressed habitats. Condensation at night is possibly the main source of water for *D. spiralis* during the dry season, and the thick mass of dried black leaves often surrounding the base of each plant may help in concentrating and retaining moisture.

Phenology:—Drosera spiralis can be found with flowers and in fruit the year round, but the main flowering period occurs during the dry season, from April to December.

Conservation Status:—Drosera spiralis has a large area of occurrence and is safeguarded by several Protection Areas, State Parks (Rio Preto, Grão Mogol), and a recently created National Park (Sempre-Vivas). It is thus here considered of Least Concern (LC) according to the IUCN (2001) categories and criteria.

Notes:—Rivadavia (1996) suggests that plants from the northern range of D. spiralis could be classified as a distinct subspecies, based mainly on their more robust habit. This variation in the leaf size is exemplified in Fig. 4, which depicts: the shorter petiole commonly observed in plants from the southern range (Fig. 4C), as well as the long petiole more common in plants of the northern range (Fig. 4D). Albeit the recorded extremes in leaf length, a continuum of variation is clear when comparing plants across the distribution range, and no other distinctive characters were observed for the northern populations which would justify separation as a distinct taxon at subspecific or varietal rank.

Drosera spiralis is the only species of the genus known to have tentacle-like emergences on the sepals as a common occurrence—and not as an anomaly (Fig. 4G, 5E). Also, large sterile bracts resembling diminutive rosette leaves, often with tentacles and even small stipules, are occasionally observed neat the apex of the scape and at the base of the inflorescence of D. spiralis. A few of these anomalous plants at different populations on the Diamantina Plateau were even observed to have their sepals transformed into minute carnivorous leaves.

White-flowered specimens of D. spiralis were observed at Grão Mogol (Rivadavia 295), but the plants had red-pigmented tentacles on the leaves, thus not representing a form entirely lacking red phytopigments. The entry labeled as D. graminifolia in the phylogenetic study of Rivadavia et al. (2003) corresponds to D. spiralis, as do both accessions used by Rivadavia (2005) to determine chromosome numbers.

November 1938, Markgraf et al. 3433 (BHC); subida para o Morro Papo da Ema, 06 September 1990, Silva et al. CFRC 13427 (F, K, MBM, NY, RB, SPF); trilha da Tropa, 02 June 1994, Rivadavia 264 (SPF), 07 September 1994, Rivadavia 295 (SPF); trilha saindo de Grão Mogol em direção oeste, 09 September 1994, Rivadavia 303 (SPF); Vale do Rio das Mortes, 24 July 1986, Zappi et al. CFRC 9940 (K, NY, R, RB, SPF, SP). Município de Itacambira, estrada para Itacambira, 16 December 1994, Rivadavia 308 (SPF); estrada para Montes Claros, 05 March 1997, Rivadavia 605 (SPF), 13 October 2001, Rivadavia 1282 (SPF); estrada Montes Claros–Itacambira (MG-308), 22 April 2010, Gonella et al. 286 (SPF), 12 February 2011, Gonella et al. 393 (SPF); Serra Resplandecente, 31 August 2003, Vasconcelos 95 (BHC); sul de Itacambira, 17 December 1994, Rivadavia 318 (SPF). Município de São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, 10 May 2004, Viana et al. 1763 (BHC); Chapada do Couto, 12 July 2007, Mota 842 (BHC); entre cachoeiras do Crioulo e Deitada, 28 June 2003, Rivadavia & Deco 1607 (SPF; entre as cachoeiras Deitada e Sempre-Viva, 28 June 2003, Rivadavia & Deco 1619, 1623 (SPF); trilha para o alto da chapada, 05 February 2009, Gonella & Viana 190 (SPF); trilha para o morro Redondo, 06 February 2009, Gonella & Viana 204 (SPF). Município de Serro, Milho Verde, extremo norte da planície ao lado da cidade, 05 April 2003, Rivadavia & Neves 1568, 1569 (SPF); à esquerda da estrada de Milho Verde para Diamantina, 06 April 2003, Rivadavia 1583 (SPF); estrada de Milho Verde para Capivari, 13 May 2007, Rivadavia 2556 (SPF). Município de Rio Vermelho, Platô Pedra Menina, 09 September 1986, Cordeiro et al. CFCR 10249 (BHC, F, MBM, R, RB, SP, SPF); Serra da Torre, 11 July 1999, Rivadavia et al. 1107 (SPF). Without location data, no date: Gardner 4417 (NY photo!).

**Discussion**

*Drosera graminifolia* and *D. spiralis* are easily distinguishable from all other Brazilian *Drosera* species by the linear leaves and appear to be closely related to a quartet of species: *D. camporupestris*, *D. chrysolepis*, *D. quartzicola* Rivadavia & Gonella (2011: 34) and *D. schwackei* (Diels 1906: 89) Rivadavia (2008: 39). All these taxa possess large bronze-gold triangular stipules (except *D. schwackei*, where they are translucent-white and rectangular), TSG trichomes (replaced by glandular capitate trichomes in *D. spiralis*), eglandular hairs densely covering the leaves, inflorescence, and sepals, as well as having a robust habit relative to most other native Brazilian *Drosera* spp. Furthermore, these taxa belong to a clade of tetraploid (or supposed tetraploid) Brazilian species with 2n=40, which also includes several taxa belonging to the *D. montana* and *D. villosa* Saint-Hilaire (1826: 267) complexes (Rivadavia et al. 2003, Rivadavia 2005).

Similar to the TSG trichomes of *D. graminifolia*, the heads of the glandular capitate trichomes of *D. spiralis* contain a yellowish translucid substance that resists evaporation when desiccated. These glandular capitate trichomes appear to be intermediate in morphology between the glandular trichomes found in many *Drosera* species and the TSG trichomes found in *D. graminifolia* and the four closely allied taxa mentioned above, suggesting that the three trichome types are possibly all homologous. As hypothesized by Rivadavia & Gonella (2011), TSG trichomes may act as specialized hygroscopic organs, helping the species that possess this indumentum to grow in relatively dry habitats by absorbing humidity from the air—an adaptive function here also assumed for the glandular capitate trichomes of *D. spiralis*.

*Drosera graminifolia* and *D. spiralis* clearly represent morphologically and ecologically distinct taxa (Table 1), as well as being geographically isolated (Fig. 1) from each other, thus supporting the specific rank. Although the leaf shape of both species is superficially very similar, *D. spiralis* has several distinguishing characteristics such as the absence of TSG trichomes, the presence of a dense indumentum of glandular capitate trichomes (Fig. 4F), shorter eglandular hairs, tentacle-like emergences often present on sepals (Figs. 4G, 5E), reduced petioles that are usually shorter than (or as long as) the stipules (Fig. 5G), and smaller ovoid seeds (Fig. 4H).
Another character distinguishing *D. graminifolia* and *D. spiralis* is the mode by which young leaves unfurl from the center of the rosettes. In *D. graminifolia* young leaves are perfectly circular and circinate, unrolling like fern fronds (Fig. 3D), whereas in *D. spiralis* they are irregularly circinate, rolled up in a variety of angles and shapes, forming an ellipse bud in outline (Fig. 5F). This difference in leaf development may be merely a result of the more voluminous leaves of *D. spiralis*, which has petioles that are semicircular to transversely elliptic in cross section (versus very narrowly transversely elliptic in the flatter leaves of *D. graminifolia*).

Although herbarium specimens of *D. graminifolia* and *D. spiralis* are easily distinguishable by the characters cited above, field work has proven to be essential for the recognition of these taxa as distinct, both morphologically and ecologically. In fact, one of the most distinctive characteristics separating *D. graminifolia* from *D. spiralis* is the habitat. While *D. spiralis* seems to be very adaptable and occupies a wide range of habitats, *D. graminifolia* occurs only in a very narrow and restricted high-montane habitat, with relatively low average and minimum temperatures and constantly higher humidity, in comparison to *D. spiralis* habitats. This habitat preference may explain the different flowering periods observed for these two species, as well as the narrow geographic endemism of *D. graminifolia*.

While fires are not a common occurrence in the high-montane habitats of *D. graminifolia* (which, similar to the sympatric flora, is not especially well adapted to survive wildfires), it is an important factor in the campos rupestres occupied by *D. spiralis*. Although the persistent dead leaves accumulated around *D. spiralis* possibly help hold humidity close to the base (representing a likely adaptation to survive the dry season), this dead leaf material is also very flammable and could pose a potential threat to the survival of these plants. However, the dead leaves have been observed to burn very fast, akin to what occurs with numerous species of the campos rupestres, especially of the Velloziaceae and Eriocaulaceae families (Alves & da Silva 2011), and thus not posing a threat to the central meristem of *D. spiralis*, which is furthermore well-insulated by the large stipules and broad succulent petioles.

*Drosera graminifolia* and *D. spiralis* superficially resemble *D. filiformis* Rafinesque (1808: 360) and *D. tracyi* (Macfarl. ex Diels 1906: 92) Macfarlane (1914: 1077) from eastern North America, which also have long, linear leaves, but can be easily distinguished by the fimbriate white stipules, absence of any kind of glandular trichomes on leaves, lack of eglandular hairs on leaves plus inflorescences, and heterophylly associated with the production of hibernacula in the winter. The similarity in leaf shape is merely a

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<th>TABLE 1. Differences between <em>D. graminifolia</em> and <em>D. spiralis</em>.</th>
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<tbody>
<tr>
<td><strong>D. graminifolia</strong></td>
</tr>
<tr>
<td>Stipule length</td>
</tr>
<tr>
<td>Length of the eglandular hairs on the abaxial surface of the petiole</td>
</tr>
<tr>
<td>Glandular trichomes</td>
</tr>
<tr>
<td>Leaf vernation</td>
</tr>
<tr>
<td>Petiole in cross section</td>
</tr>
<tr>
<td>Petiole length</td>
</tr>
<tr>
<td>Leaf apex</td>
</tr>
<tr>
<td>Tentacles on sepals</td>
</tr>
<tr>
<td>Seed shape and size</td>
</tr>
<tr>
<td>Main flowering period</td>
</tr>
<tr>
<td>Distribution</td>
</tr>
</tbody>
</table>
convergence, since *D. filiformis* and *D. tracyi* are actually more closely related to other North American species belonging in a clade of mostly small rosetted, diploid sundews with 2n=20 (Rivadavia et al. 2003). Linear leaves are such a rare occurrence among *Drosera* spp. that this one character appears to have gained undue taxonomic weight and caused obfuscation of all other characters in most prior studies involving *D. graminifolia* and *D. spiralis* (similarly with *D. filiformis* and *D. tracyi*). If instead of linear leaves these taxa had a more common spatulate shape, other characters (such as the distinctive differences in overall indumentum, stipule and seed size and shape, relative petiole length, as well as habitat and ecology) would not have been so easily overridden, and would probably have already been recognized as clear justifications for the maintenance of *D. graminifolia* and *D. spiralis* as separate—albeit closely related—species, in agreement with Saint-Hilaire (1826).

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**References**


Rafinesque, C.S. (1808) Prospectus of Mr. Rafinesque Schmaltz’s two intended works on North American botany; the first on the new genera and species of plants discovered by himself, and the second on the natural history of the funguses, or mushroom-tribe of America. *Medical Repository*, ser. 2, 5: 360.
RE-ESTABLISHMENT OF DROSERA SPIRALIS

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