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## A New and Tuberos Species of *Genlisea* (Lentibulariaceae) from the *Campos Rupestres* of Brazil

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**Abstract**—A new species, *Genlisea tuberosa*, is described from the *campos rupestres* of central and eastern Brazil. A detailed description, line drawings, photographs and SEM photomicrographs of the seeds are provided for the new species, together with remarks on ecology, distribution and habitat. The characters distinguishing *G. tuberosa* from similar taxa are discussed.

**Resumo**—Uma nova espécie, *Genlisea tuberosa*, é descrita para os campos rupestres do Brasil central e leste. São fornecidas para a nova espécie uma descrição detalhada, ilustrações, fotografias e fotomicrografias em MEV das sementes, bem como comentários sobre ecologia, distribuição e habitat. As características distinguindo *G. tuberosa* de táxons similares são discutidas.

**Keywords**—Chapada dos Veadeiros, Espinhaço Range, *Genlisea*, Serra da Canastra, taxonomy.

The genus *Genlisea* A.St.-Hil. belongs to the carnivorous plant family Lentibulariaceae, and comprises 27 species (Fleischmann et al. 2010, 2011) occurring in sub-Saharan Africa (including Madagascar), tropical and subtropical South America, and Central America (including Cuba) to Southern Mexico. The Central Brazilian highlands represent the main diversity center of the genus, where both subgenera (*G.* subgen. *Genlisea* and *G.* subgen. *Tayloria* (Fromm) Eb.Fisch., S.Poremski & Barthlott) occur. In this region, most *Genlisea* species are endemic to the *campos rupestres* (“rocky fields”) vegetation type (Fleischmann et al. 2011).

In the late 1980s, a tuberous *Genlisea* was found near the town of Diamantina, Minas Gerais state, by the carnivorous plant specialist Thomas Carow. In his carnivorous plant book, he assigned the plant to *G. pygmaea* A.St.-Hil. and described its tuber-forming habit: “*Genlisea pygmaea* forms little tubers to survive the dry season” (Carow and Fürst 1991). Unfortunately no herbarium specimens were made, and the tubers were later believed to have belonged to a different plant other than *Genlisea*.

During a trip to the Chapada dos Veadeiros highlands of north-eastern Goiás state, during the dry season in 2007, a tuberous *Genlisea* was rediscovered by the first author (Rivadavia 2007). Similar tuber-bearing plants were also found by the authors near Cristalina in 2007, São Gonçalo do Rio Preto in 2009, Diamantina in 2010, and reported (as *G. pygmaea*) by da Silva et al. (2011) to the Serra de São José, southern Minas Gerais.

A close examination of these tuberous specimens revealed several characteristics that distinguish them from other known yellow flowered *Genlisea* species, and they are here described as a new species.

### MATERIALS AND METHODS

For SEM analysis, seeds of *Genlisea tuberosa* were taken from herbarium specimens (*Rivadavia 2611*), mounted on lightstub carbon plates, gold coated in a SCD 050 sputter coater (BAL-TEC, Liechtenstein), and then observed in a 438VP scanning electron microscope (LEO, Germany). Seeds from the same voucher were germinated without further treatment on moist peat under artificial lights at room temperature, to study early seedling ontogeny and tuber formation. One of the germinated seedlings is illustrated in Fig. 1. The distribution map (Fig. 2) was created with

DIVA-GIS (Hijmans et al. 2005), based on the spatial cartographic data provided by the Brazilian Institute of Geography and Statistics (IBGE: <http://www.ibge.gov.br>).

### TAXONOMIC TREATMENT

***Genlisea tuberosa*** Rivadavia, Gonella & A.Fleischm. *sp. nov.*—TYPE: BRAZIL. Minas Gerais: São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, trilha para o alto da chapada, em campo brejoso do lado direito da trilha, 1228 m, 5 February 2009, *Gonella & Viana 194* (holotype: SPF!).

*Genliseae aureae* A.St.-Hil. affinis minoribus, tuberifera, sed scapis e basi pilis eglanduligeris sparsis obsitis, ad apicem pilis glanduligeris et eglanduligeris, floribus paucis et minoribus, pedicello corolla 3plo longiore, calcar corollae labio inferiore circa 2plo longiore.

Rosetted perennial herb, up to 13 cm tall, forming subterranean obovoid to globose tubers 2–9 × 1.5–8 mm, yellowish-white in color, at the apex of short vertical stolons (up to 3.5 mm long); rosette dense and compact, on very short ephemeral stem, leaves in living plants usually covered by translucent mucilage (mucilage not visible in dried specimens). Leaves spatulate, 7.5–20(25) mm long; petiole 5–13.5(20) × 0.5–0.8(–1.2) mm, inflated, subterranean, white in color, grading into the lamina; lamina obovate to broadly obovate, rarely elliptic, 2–6.5(–8) × 2–4 mm; rhizophylls with subglobose to ellipsoid vesicle 0.6–1 × 0.4–0.65 mm. Inflorescence a raceme, with 1–2(–3) flowers per scape; scapes, bracts, bracteoles and calyx densely covered with indumentum of glandular hairs 0.2–0.5 mm long and simple eglandular hairs 0.1–0.3 mm long (very rarely indumentum consisting exclusively of eglandular hairs [some specimens of *Rivadavia 645*]). Scape 1, erect, terete, dark green to blackish-purple, (25–)42–120 mm long, 0.3–0.5 mm diam. at the base, scape usually furcate, as the apical growth tip of the peduncle is frequently aborted and overtopped by a lateral shoot formed from the subjacent bract; lower part of the scape with 3–5 dispersed sterile, scale-like bracts; basal 1/3–2/3 of the scape and the sterile bracts covered with eglandular patent hairs, apical part of the scape sparsely to densely covered

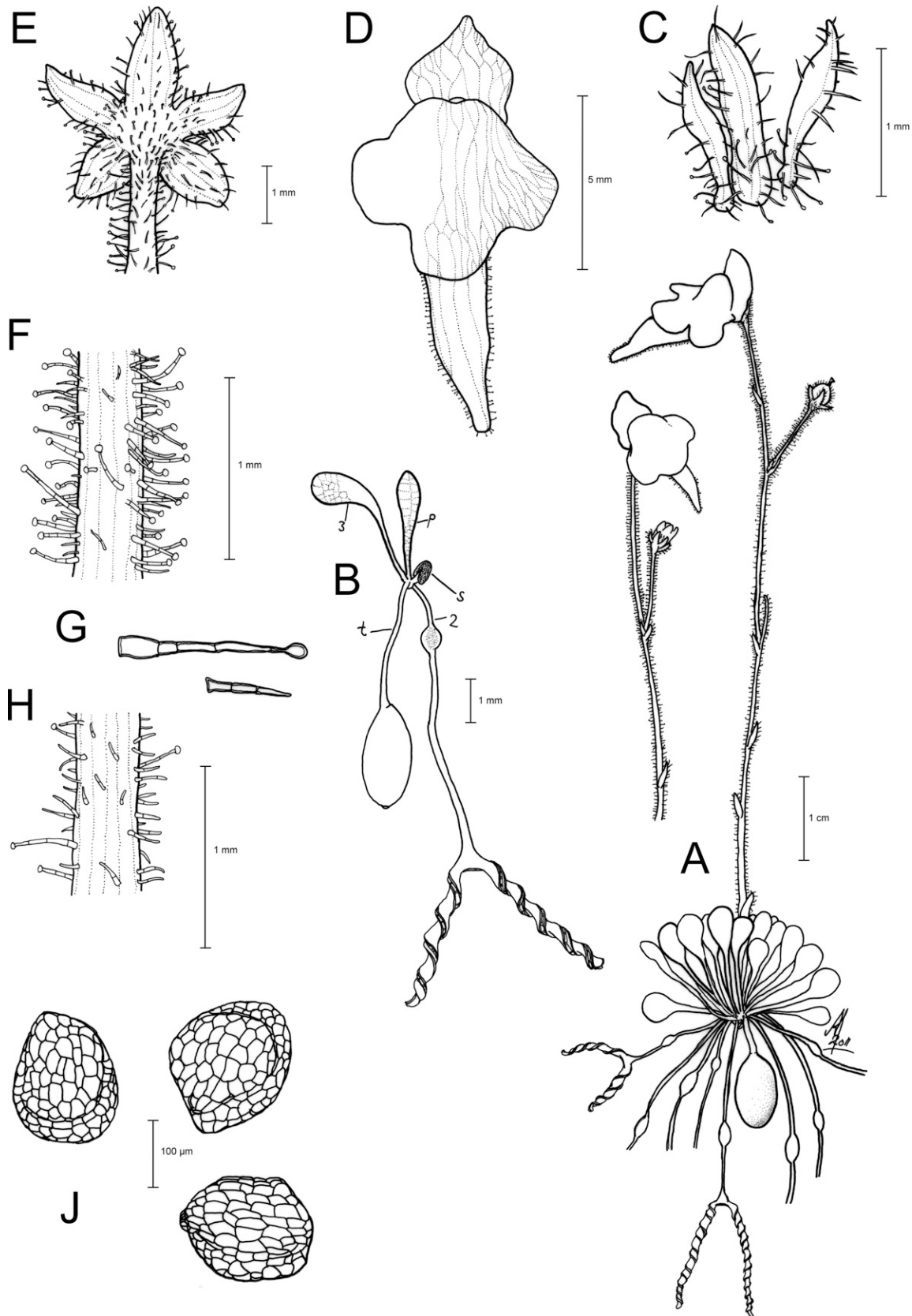


FIG. 1. *Genlisea tuberosa*. A. Habit. B. Seedling, germinated from seed from *Rivadavia* 2611; s = seed coat, p = primary leaf, 2 = second leaf formed in ontogeny (rhizophyll), 3 = third leaf (photosynthetic leaf), t = tuber-bearing stolon. C. Bract and bracteoles. D. Corolla. E. Calyx. F. Upper part of the scape. G. Glandular and eglanular hair from upper part of the scape. H. Lower part of the scape. J. Seeds. A., D., E. from *Gonella & Viana* 194; C., J. from *Rivadavia* 2611; F.–H. from *Irwin et al.* 11456. Drawing by A. Fleischmann.

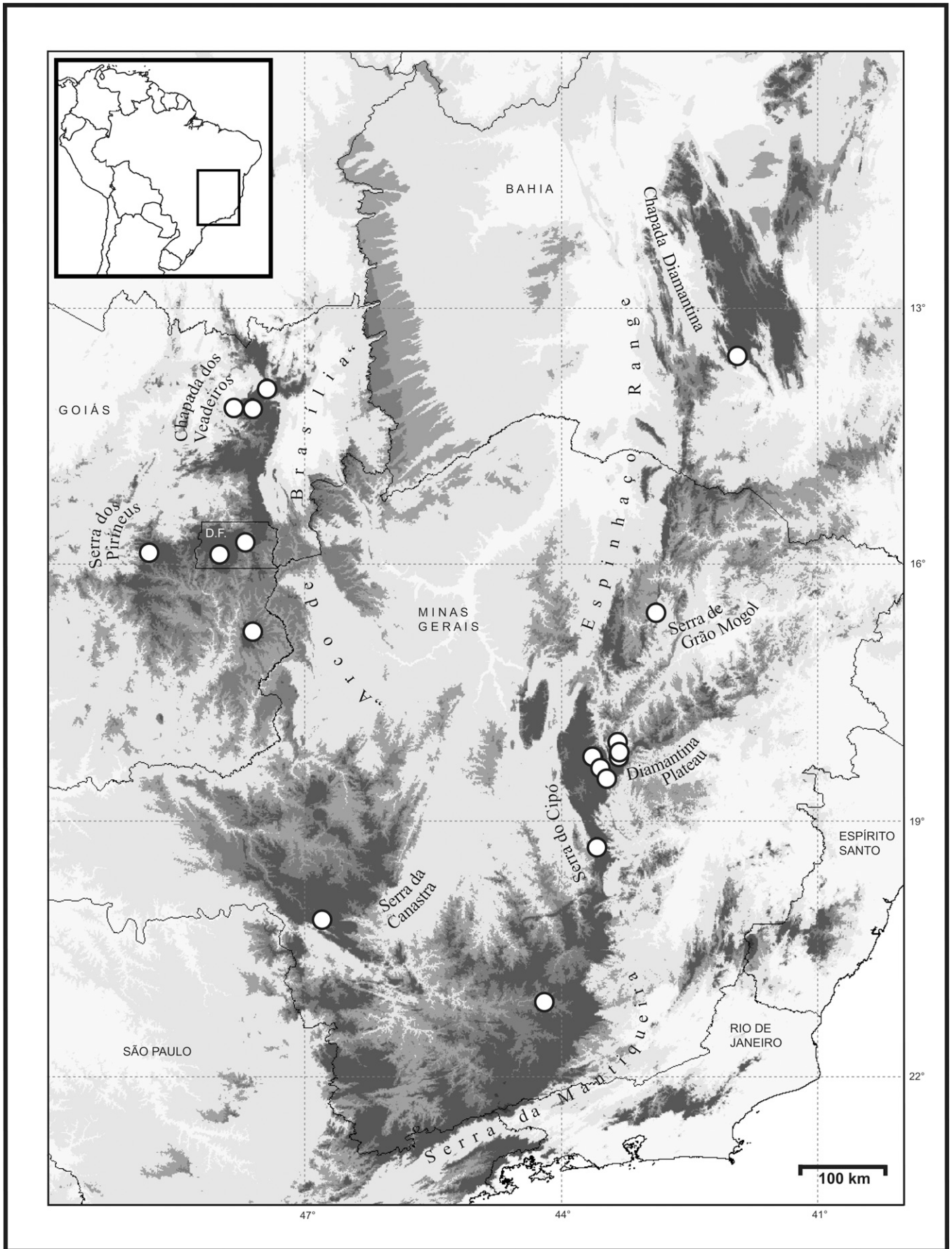


FIG. 2. Distribution of *Genlisea tuberosa*.

with both glandular and eglandular hairs; all hairs seriate, ca. 0.2–0.5 mm long, eglandular hairs somewhat shorter than the glandular hairs (glandular hairs absent in few exceptional specimens of *Rivadavia* 645). Bracts ovate to lanceolate, 0.7–1.6 × (0.25–)0.4–0.6(–0.8) mm, from slightly gibbous base, with apex acute, covered with eglandular patent hairs, occasionally with sparse glandular hairs. Bracteoles subulate, narrowly lanceolate or linear, 0.7–1.6 × 0.2–0.4 mm, with apex acute or rarely truncate, indumentum similar to the bracts. Pedicel terete, 3.5–12(–20) mm long, (0.1–)0.2–0.4 mm diam., erect at anthesis and in fruit, densely covered with both glandular and eglandular patent hairs, glandular hairs becoming denser towards apex (glandular hairs lacking in a few exceptional individuals of *Rivadavia* 645). Sepals 5, subequal, lateral and median ones subulate to lanceolate, basal ones more ovate, (1–)1.2–2 × 0.3–0.7(–1) mm, densely covered with both glandular and eglandular patent hairs (glandular hairs absent in some exceptional specimens of *Rivadavia* 645). Corolla bilabiate, 6.5–11.5 mm long, yellow, with gibbous palate; upper lip entire, broadly ovate, 2–3 × 2–3.3 mm, slightly paler than the lower lip, apex rounded, lateral margins distinctly reflexed; lower lip transversely elliptic in outline, 4–7.5 × (3–)3.6–5.5 mm, shallowly trilobate, lobes subequal (the median one slightly longer), palate papillose; spur narrowly conical from widened base, apex acute, 5–7.5 (–10) mm long, parallel to and at least twice as long as the lower corolla lip, ca. 1–2 mm diam., the apex curved downwards; corolla margins glabrous, corolla lower surface and spur covered with short-stalked glandular hairs. *Capsule* globose, 2.5–3 mm diam, covered with glandular hairs and simple eglandular hairs, opening circumscissile. *Seeds* obovoid to slightly angular, yellowish-brown, 180–200(–250) μm long, (130–)150–180 μm wide, 80–100 μm high; testa reticulate, the testa cells elongate to isodiametric, 4–6 angular, the anticlinal walls sunken, the periclinal walls slightly convex to tabular, microscopically verrucose. Figures 1, 3.

**Distribution and Ecology**—Brazil: Bahia, Goiás, Distrito Federal, and Minas Gerais. *Genlisea tuberosa* is restricted to *campos rupestres* vegetation, and occurs along the Espinhaço Range (in the southern end of the Chapada Diamantina, Serra de Grão Mogol, Diamantina Plateau, and Serra do Cipó), at the Serra de São José (south-eastern Minas Gerais), and on the highlands of the “Arco de Brasília” (“Bow of Brasília”; Ross 1996): the Serra da Canastra (south-western Minas Gerais), and on the highlands of the Planalto Central (Cristalina, Serra dos Pirineus, Chapada da Contagem, and Chapada dos Veadeiros) (Fig. 2). This pattern of distribution along the Espinhaço Range and central Brazilian highlands has been reported for other plant species as well, e.g. species of *Chamaecrista* Moench (Fabaceae – Caesalpinioideae), characteristic plants of the *campos rupestres* vegetation (Rando and Pirani 2011).

*Genlisea tuberosa* occurs in seasonally wet areas in montane to high-montane regions (800–1500 m), on fast-draining sandy quartzitic soils in open places, or among sparse grasses. It has been observed growing sympatrically with *G. aurea* A.St.-Hil., *G. filiformis* A.St.-Hil., *G. violacea* A.St.-Hil., and other carnivorous plants, such as several species of *Utricularia* L. (Lentibulariaceae) and *Drosera* L. (Droseraceae).

**Phenology**: Seasonal tuberous geophyte. Flowering specimens have been collected between February and June. A dormancy period is observed by *G. tuberosa* during the winter dry season (approximately from May to November, in

central-eastern Brazil), when it survives as subterranean tubers, whilst the vegetative and generative parts above soil desiccate and decay. Growth from the tubers starts early in the wet season, allowing plants to exhibit fully developed rosettes and flowers at a time when sympatric annuals – such as *G. filiformis* – are just beginning to emerge from their dormant seeds (Rivadavia 2007).

The secretion of a thin layer of clear mucilage from the rosette leaves is known from *G. tuberosa*, but to a lesser degree in comparison to *G. aurea* (Rivadavia 2000, 2002, 2007; Fleischmann 2010; erroneous reports of mucilage on the leaves of *G. filiformis* (Płachno et al. 2005) are a result of misidentified specimens of *G. aurea*). The mucus is secreted from sessile mucilage hairs, which were described and illustrated from the leaves of *G. aurea* by Goebel (1891). This mucilage may serve as a protection against herbivores (Rivadavia 2000, 2002; Płachno et al. 2005), or possibly act as a mechanical barrier to keep the rosettes from becoming overgrown by surrounding mosses and algae (Fleischmann 2010). A protective function against desiccation – as further postulated by Płachno et al. (2005) – seems unlikely, as the mucus is only produced when the plants are in active growth under humid conditions.

In *G. tuberosa* mucilage production slows at the beginning of the dry season as the rosettes wilt and finally die. A seasonal reduction in mucilage production is also observed in *G. aurea* populations occurring in drier habitats, although most often this species grows in permanently wet habitats, where mucilage production continues throughout the winter (Rivadavia 2000, 2002). Interestingly, plants of *G. aurea* growing in shaded conditions seem to produce more copious amounts of mucilage on their rosettes when compared to plants growing exposed to full sun (Rivadavia 2002).

**Etymology**—The epithet *tuberosa* refers to the tuber forming habit of this new species, a unique feature among *Genlisea*.

**Conservation Status**—According to the criteria by IUCN (2001) Red List *G. tuberosa* is considered as Least Concern (LC) due to its wide geographical distribution and the fact that several populations are protected within State and National Parks.

**Additional Specimens Examined**—BRAZIL: Bahia: Lower NE slopes of the Pico das Almas, ca. 25 km WNW of the Vila do Rio de Contas, 17 February 1977, Harley et al. 19566 (K). Goiás: Serra dos Pirineus, c. 18 km E of Pirenópolis, 1000 m, 15 January 1972, Irwin et al. 34211 (NY photo!); Alto Paraíso, Chapada dos Veadeiros, 5 km E of Alto Paraíso, 1500 m, 25 January 1979, Gates & Estabrook 51 (K); Alto Paraíso de Goiás, trilha para cachoeira Santana, 1 February 1993, Rivadavia 188 (SPF); Alto Paraíso de Goiás, Povoado de São Jorge, PARNA da Chapada dos Veadeiros, 10 April 1995, Rivadavia et al. 363 (SPF); Alto Paraíso de Goiás, Chapada dos Veadeiros, km 196 da estrada Alto Paraíso-Teresina de Goiás, 1400 m, 19 March 1997, Rivadavia 645 (SPF), 23 June 2007, Rivadavia & Batista 2611 (SPF), 8 August 2012, Gonella & Rivadavia 574 (SPF); Alto Paraíso de Goiás, PARNA Chapada dos Veadeiros, depois de Alto Paraíso de Goiás, 22 March 2012, Baleiro et al. 135 (SPF). Distrito Federal: Chapada da Contagem, ca. 15 km E of Brasília, 8 January 1966, Irwin et al. 11456 (K); Brasília, Fazenda Supupira, arredores da “Mata Sem Nome”, próximo a pequena barragem artificial local, 10 January 2001, Water & Guarino 4706 (CEN). Minas Gerais: Diamantina, serra ao NW da cidade, 27 February 1997, Rivadavia & Pinheiro 579 (SPF); Diamantina, ao Sul da cidade, 1250 m, 20 April 2010, Gonella et al. 419 (SPF); Grão Mogol, estrada para o rio Ventania, 25 February 1986, Menezes et al. CFCR 9653 (SPF); Grão Mogol, Trilha da Tropa, 2 June 1994, Rivadavia 273 (SPF); Jaboticatubas, estrada para Conceição do Mato Dentro, 4 April 2003, Rivadavia 1547 (SPF); Jaboticatubas, Fazenda da Serra do Cipó, 26 February 1992, Rivadavia 91 (SPF), 25 February 1997, Rivadavia & Pinheiro 554 (SPF); São Gonçalo do Rio Preto, Parque Estadual do Rio Preto, c. 1 km depois da portaria, 4 February 2009, Gonella & Viana 179 (SPF); São Gonçalo do Rio Preto, PERP, trilha para o Morro Redondo, 6 February 2009, Gonella & Viana

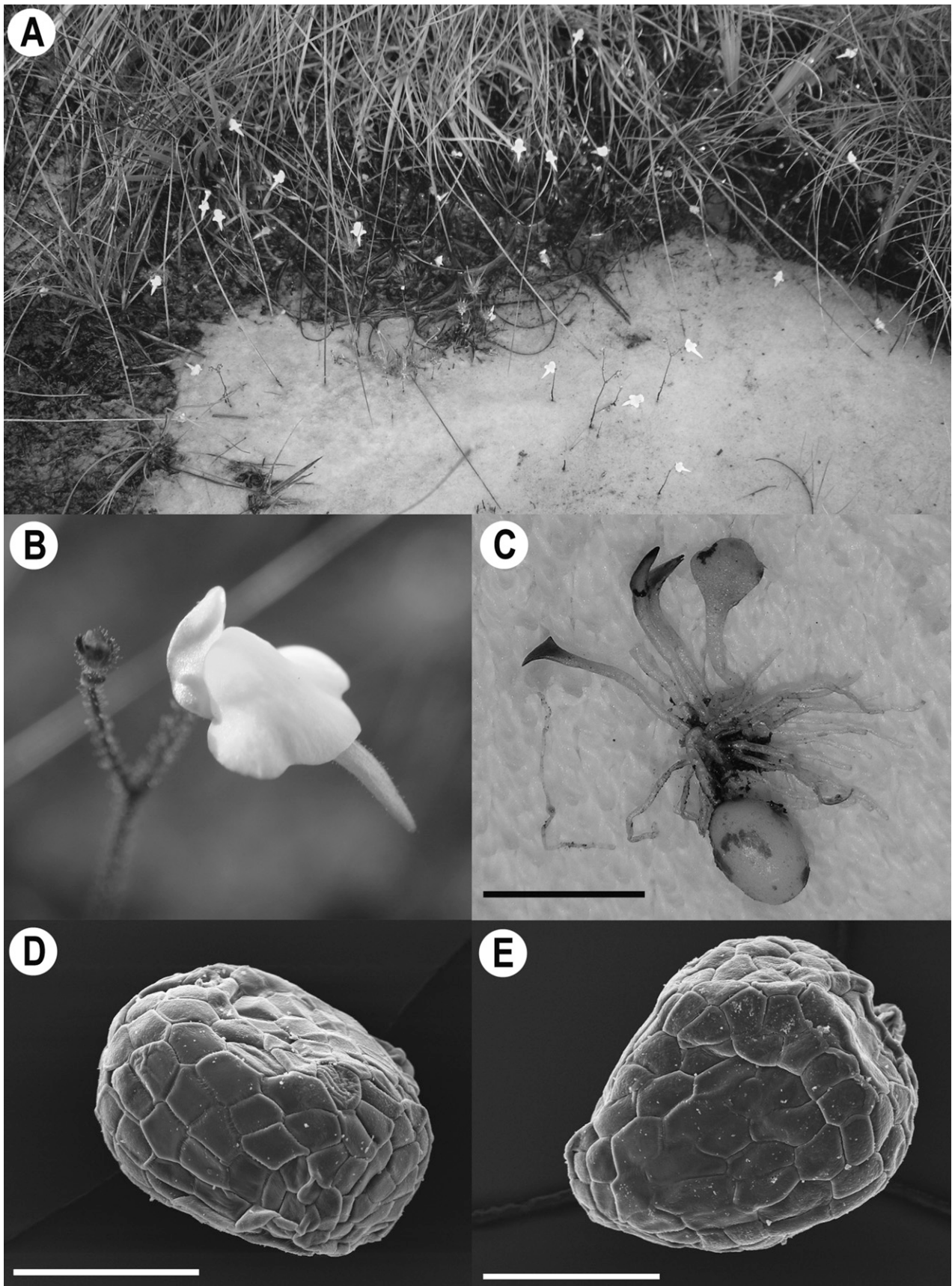


FIG. 3. A. *Genlisea tuberosa* growing in wet sand at the *locus classicus*. B. Close-up of the corolla. C. Excavated plant (scale bar = 1 mm). D, E. SEM photomicrographs of the seeds (from Rivadavia 2611). D. Lateral view (scale bar = 100  $\mu$ m). E. Distal view (scale bar = 100  $\mu$ m).

TABLE 1. Comparative diagnostic characteristics between *G. tuberosa*, *G. aurea* and *G. pygmaea*.

	<i>G. aurea</i>	<i>G. pygmaea</i>	<i>G. tuberosa</i>
Life strategy	perennial hemicryptophyte	annual therophyte	perennial geophyte
Tubers	absent	absent	present
Indumentum at the base of the scape	densely glandular	subglabrous	densely eglandular
Indumentum of the apex of the scape, pedicel and calyx	densely covered with glandular hairs	scape glabrous, pedicel sparsely glandular, sepals densely covered with eglandular hairs	densely covered with both glandular and eglandular hairs
Number of flowers per scape	(1-)4-6(11)	1-7	1-2(3)
Corolla length	(12)14-24 mm	(2.5)4-5(8) mm	6.5-11.5 mm
Spur shape	cylindrical to narrowly conical, acute, gradually curved towards the lower lip	broadly conical, obtuse, straight	narrowly conical, acute, straight with apex suddenly curved downwards
Spur length in relation to the lower corolla lip	spur equal to or slightly longer than the lower corolla lip (up to 1.5 times longer)	spur slightly longer than lower corolla lip (rarely equalling)	spur much longer than lower corolla lip (twice as long or more)

205 (SPF); São Roque de Minas, PARNA da Serra da Canastra, estrada que atravessa o Parque, 1400 m, 4 April 1999, *Rivadavia & Peixoto 896* (SPF); Serro, Milho Verde, trilha para a cachoeira do Arco-Íris, 1100 m, 5 April 2003, *Rivadavia & Neves 1557* (SPF); Serro, estrada de Milho Verde para Diamantina, 6 April 2003, *Rivadavia 1582* (SPF); Tiradentes, Serra de São José, *Silva 277* (R).

#### DISCUSSION

*Genlisea tuberosa* is placed in *Genlisea* subgen. *Genlisea* section *Genlisea* (Fleischmann et al. 2010) because of its capsule dehiscence (multiple-circumscissile), spur orientation (parallel to the lower lip of the corolla), and biogeography (Neotropical member of subgen. *Genlisea*). This new species is most closely related to *G. aurea*, with which it shares the mucilaginous rosette, the dense indumentum of glandular hairs on pedicels and sepals (although not exclusively glandular in *G. tuberosa*), and the narrowly conical spur with a densely glandular indumentum and acute apex.

The sister relationship of *G. aurea* and *G. tuberosa* is also confirmed by molecular and cytogenetic data (in prep.). The flowers of *G. tuberosa*, however, are much smaller than those of *G. aurea*; the corolla is not exceeding 11.5 mm in length (including the long spur) and 7.5 mm in width in *G. tuberosa* (in *G. aurea* (12)14-24 mm long and 8-20 mm wide). Unlike *G. aurea*, *G. tuberosa* has a spur that is at least about twice as long as the lower corolla lip, straight, however often distinctly and suddenly curved downwards at about half length (longer than or equalling the lower corolla lip, straight or with apex gradually curved upwards) (Table 1)

Other distinctive characters, which immediately distinguish *G. tuberosa* from *G. aurea*, are the much thinner scapes of up to 0.5 mm diam. (at least 0.7-2.5 mm diam. in the thick, succulent scapes of *G. aurea*), the relatively longer pedicels (pedicels about 1-1.5(-2) times longer than the corolla in *G. tuberosa*, and only have up to half the length of the corolla at maximum in *G. aurea*), and the less compact, seasonally formed rosettes consisting of broadly spatulate leaves on a short, ephemeral stem (*G. aurea*: very compact, perennial, subglobose rosettes consisting of narrowly spatulate leaves which are densely arranged on persistent, long and often dichotomously branched stems).

Although previously mistaken with the delicate annual *G. pygmaea*, *G. tuberosa* is easily distinguished by its more robust habit and larger vegetative and generative parts, especially by the larger corolla with a narrowly conical spur

that is much longer than the lower corolla lip (corolla ca. 3.5 mm long, spur saccate to broadly conical with slightly acute apex, only slightly exceeding the lower corolla lip in *G. pygmaea*), and indumentum of the scapes, pedicels and sepals (Table 1). The broadly conical and short spur, as well as the characteristic indumentum of *G. pygmaea* suggest that this species may be most closely related to the morphologically similar *G. filiformis* (Saint-Hilaire 1833; Saint-Hilaire and Girard 1839).

Although the production of stolon-derived tubers is known in Lentibulariaceae from a few species of *Utricularia* L., such as the terrestrial *U. menziesii* R.Br. from Australia, and some epiphytic and lithophytic species from South America, Africa, and Asia (Taylor 1989), this is the first known *Genlisea* species that produces these storage organs.

The tubers are an adaptation to survive the dry season in habitats that suffer intense desiccation, and are produced very early in the ontogenetic development of *G. tuberosa*. The first leaf produced in *Genlisea* is always a green leaf, followed by a trap leaf - in *G. tuberosa* the third organ produced is a green leaf, and then already the tuber is formed on a stolon (Fig. 1 B). In cultivated plants of *G. tuberosa*, the production of smaller adventitious tubers from the main rosette was observed, which may be a strategy for vegetative propagation of this species.

The fact that the tubers detach easily when collected explains their absence in several herbarium specimens of *G. tuberosa*. Moreover, many herbarium specimens of both *Genlisea* spp. and terrestrial *Utricularia* spp. are often collected by simply pulling out the flowering scapes in the field, the vegetative organs remaining detached and buried in the soil. This led to the erroneous belief that some species of *Utricularia* and *Genlisea* are lacking leaves when in flower (see Taylor 1989). For example, Saint-Hilaire (1833) and Saint-Hilaire and Girard (1839) described *G. pygmaea* as a "*Genlisea aphylla*" - as a plant lacking leaves when in flower. Although this is certainly not the case, the small annual *G. pygmaea* often inhabits sandy soils, where their rosettes are often covered underneath a layer of sand.

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