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Brazilian plants urgently needing conservation: the case of *Vriesea minarum* (Bromeliaceae)

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Abstract

Difficulties in identifying *Vriesea minarum* as well as a conflict of interest among mining companies and local conservationists are pushing this species towards extinction. *Vriesea minarum* was categorised as data deficient in the Brazilian official plant red list despite earlier works indicating its vulnerability. This species is restricted to the Iron Quadrangle area, Minas Gerais, Brazil, where it grows over iron rock outcrops. Here we use *V. minarum* to illustrate the importance of taxonomic investigation as well as the presentation of accurate distributional data in order to establish conservation strategies. We emphasize the importance of well-conserved herbaria collections and adequate type material to avoid taxonomic issues that delay the understanding of species limits. This paper presents taxonomic notes and the redefining of *V. minarum* based on the survey of 22 herbaria collections and fieldwork. The additional material obtained and a morphometric approach allowed us to better delimit the related taxa. The species *V. ouroensis* is considered to be a new synonym of *V. minarum*. A map showing the occurrences of populations of *V. minarum*, pictures of living specimens in the field, as well as its updated conservation status are provided. Historic records housed in herbaria indicate that this species has been progressively losing its area of occurrence.

Key words: endemism, Espinhaço range, Iron Quadrangle, metallophytes, mining, Tillandsioideae

Introduction

The state of Minas Gerais (MG) is located in the southeast of Brazil and has an elevated number of bromeliad species that occur in a wide variety of vegetation types (Versieux & Wendt 2007). Inside MG, the genus *Vriesea* is notable by presenting the highest number of species (Versieux & Wendt 2006). The main area of endemic Bromeliaceae within MG is the Espinhaço mountain range (Versieux *et al.* 2008). This mountain range is considered to be floristically one of the richest areas in South America (Giulietti *et al.* 1997), and hosts along its southernmost portion a region (~7,000 km^2) known as the Iron Quadrangle (IQ) or, in Portuguese, Quadrilátero Ferrífero (Dorr 1965). The origin of this name relates to the almost square-shaped geographic orientation of the mountain ranges rich in high-grade iron ores present there. This is one of the most important iron ore mining districts in the world (Dorr 1965, Dardenne & Schobbenhaus 2001, Spier *et al.* 2003).

This economic and biologically rich area is responsible for the majority of the iron ore produced in Brazil, besides other deposits of gold and manganese as well as other minerals (Dardenne & Schobbenhaus 2001). The IQ is an ecotonal area that has extremely rich vegetation composed of a mosaic of semi-deciduous seasonal forest, savannas, open fields, and rupicolous vegetation over iron ore or quartzitic outcrops (Jacobi *et al.* 2007, Viana & Lombardi 2007, Versieux *et al.* 2011). The IQ is a hotspot for Bromeliaceae and also shelters endemic and endangered species of birds among other organisms, being considered one of the top priority areas for conservation within the whole state of MG (Drummond *et al.* 2005, Versieux & Wendt 2007, Vasconcelos & Rodrigues 2010). All over the world the flora of metalliferous soils is threatened by human activities, especially mining (Faucon *et al.* 2010) and this scenario is no different within the IQ. In this region

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the iron ore outcrops are particularly interesting due to their narrow and insular distribution estimated to occupy less than 100 km^2, and their high floristic alpha and beta diversity of plants adapted to high metal concentrations in the soil and is full of endemic species (Jacobi *et al.* 2007, Jacobi & Carmo 2008).

During the fieldwork for the checklist of Bromeliaceae of MG we observed that *Vriesea minarum* Smith (1943: 118) is restricted to the iron rock outcrops of the IQ, usually occurring above 1000 m elevation. Our concern with this species was enhanced when we noticed that its populations were being severely destroyed by iron ore extraction, fires, and the expansion of cities and roads in this populated area. In spite of this, the species could be considered as part of a complex, including other species frequently misidentified in herbaria, such as *Vriesea atropurpurea* Silveira (1931: 3), *V. botafogensis* Mez (1894: 536), *V. citrina* E.Morren ex Baker (1889: 224), *V. densiflora* Mez (1894: 567), *V. stricta* Smith (1943: 122), *V. tweedieana* (Baker) Mez (1894: 561) and *V. ouroensis* Weber (1986: 106). These facts highlighted the importance of proceeding to revise this group, here designated the *V. minarum* complex.

We assumed that the difficulties of identifying *V. minarum* and related taxa and the consequent lack of detailed knowledge on their distribution and status has resulted in them being largely ignored by earlier red lists of threatened taxa and also by the governmental agencies related to biodiversity conservation. Subsequently, even with detailed data available in the literature, the treatment of the species has been controversial. The statutory agencies included it in the Data Deficient appendix of Brazilian official plant species' red list (Ministério do Meio Ambiente 2008). Its taxonomic limits have been confused by the existence of other names, including another species described with inexact provenance whose holotype has been lost for some time.

Ignored by official protection regulation on one hand, involved in a taxonomic issue on the other, and growing over iron ore and gold-rich substrates, this species faces the possibility of becoming extinct in the wild in the near future if no action is taken. This study treats aspects of the taxonomy and conservation of *V. minarum* and suggests actions to protect it and its populations. The following questions are being addressed: 1) what conclusions can be drawn from the re-evaluation of the circumscriptions and from the morphological studies of *V. minarum* and its morphological similar congeners? 2) What are the habitat and the actual geographical distribution of *V. minarum*? 3) What is the current conservation status of *V. minarum*?

Material and methods

The morphological description is based on the examination of herbarium collections and on new material collected by the author, spirit preserved tissues, and from field and greenhouse observations of living plants. All the original descriptions of taxa involved in this complex were consulted for comparative taxonomic and nomenclatural analysis. Data on the distribution was obtained from herbaria BHCB, BHZB, C, CESJ, GH, HAL, HB, HBR, K, MBM, MO, NY, P, R, RB, RFA, SEL, SP, SPF, UB, US, and VIC. Surveys at the type localities and searches for populations were carried out between the years 2004 and 2010 in the IQ. The morphometric data was collected from herbarium specimens using a calliper. All the examined specimens are cited in Appendix 1. A total of 31 individuals of *V. minarum* and 16 of *V. stricta* were investigated covering the entire geographical range of both species. The other species were less frequently represented in herbaria, but the available specimens were also included (see Appendix 1). The conservation status of *V. minarum* is discussed based on IUCN criteria (2001), taking data into account observed during visits to the populations in the field.

Results

Taxonomic history

Vriesea minarum presents a confusing taxonomic history. Specimens of this species have been placed under different identifications in the last two centuries. Mostly the species was misidentified and confused with other rupicolous yellow-flowered *Vriesea* species. A summary of the history of *V. minarum* is presented in Table 1, in which it can be noted that different names have been applied to this species in the past.

TABLE 1. Taxonomic history of *Vriesea minarum* L.B. Sm.

Author	Taxonomic position or circumscription adopted
Baker (1889)	Published the name *Tillandsia citrina* Baker, based on two Brazilian specimens (syntypes): one from Minas Gerais state, Serra da Piedade, *Warming 2176* (C), and another collection from Rio de Janeiro, Botafogo, May 1887, *Glaziou 16466* (K).
Mez (1894)	Published *Vriesea botafogensis* based on a collection (isosyntype) used by Baker (1889) to describe *T. citrina*: *Glaziou 16466* (B), without mentioning this fact.
Mez (1894)	Treated the other syntype of *T. citrina*, i.e. *Warming 2176* (C) together with other specimens collected by *Sellow 70* (P), *302* (C), *1311* (B), from Minas Gerais, Serra do Caraça, as *Vriesea tweedieana* including the type collection of that species: *Tweedie 1342* (K).
Mez (1934)	Remained of the same opinion as in Mez (1894) regarding specimens and identification.
Smith (1943)	Described *V. minarum* from a specimen collected by Mulford & Racine Foster at Serra da Piedade, mun. Caeté, Minas Gerais, *Foster 564* (GH).
Smith (1955)	Treated *Tillandsia citrina* as well as *T. tweedieana* as synonyms of *V. rodigasiana* Morren (1882: 171).
Smith (1971)	Published the new combination *V. citrina* (Baker) L.B.Sm. and indicated that the specimen *Warming 2176* (C) should be the type of *Tillandsia citrina* Baker. Placed *V. minarum* as a synonym of *V. citrina*, which was delimited using only specimens from the Iron Quadrangle.
Smith & Downs (1977)	Placed *V. citrina* and *V. minarum* as synonyms of *V. atropurpurea*.
Weber (1986)	Described *Vriesea ouroensis* (Fig. 1).
Leme (1999)	Revised the synonymy of *V. atropurpurea* proposed by Smith & Downs (1977) and re-establishes *Vriesea citrina* (= *V. minarum*) as an independent species.
Grant *et al.* (2002)	Concluded that *Tillandsia citrina* (the basionym of *Vriesea citrina*) was a posterior homonym of *T. citrina* Burchell ex Baker. Thus this name should not be used. Re-established *V. minarum*.

Systematic treatment

Vriesea minarum L.B. Sm., *Arq. Bot. Estado São Paulo* 1: 118. (Smith 1943). (Figs. 1, 2A–2 A-F). Holotype: BRAZIL. Minas Gerais: Mun. Caeté, Serra da Piedade, 1300 m, 10 July 1940, *M. & R. Foster 564* (GH!).

Tillandsia citrina Baker (1889: 244), *non* Burch. ex Baker (1879). *Vriesea citrina* E. Morren ex Baker (1889: 244), *pro syn. Vriesea citrina* (Baker) L.B. Sm., *Phytologia* 21: 93. 1971. Lectotype (designated by Smith 1971): BRAZIL. Minas Gerais: Mun. Caeté, Serra da Piedade, in alpestribus saxosis, 4–5000 ft, *Warming 2176* (C!).

Vriesea ouroensis W. Weber, *Feddes Repert.* 97: 106. 1986. Holotype: BRAZIL. Minas Gerais: Mun., Ouro Preto, 1050 m, 1982, *A. Seidel 929* (HAL!), *syn. nov.*

Plant growing rupicolous, 35–70(–90) cm tall; rosette 19–34 cm tall, tubular to narrowly infundibuliform. Leaves 7–22, erect to suberect, frequently persistent; sheath 6–16 × 4.7–7.4(–9.0) cm, elliptic to ovate, densely brown-lepidote; blade 9.5–29.0 × 3–6 cm, ligulate, glaucous, sometimes purplish-red toward the apex, apex rounded and shortly apiculate. Peduncle 30–45(–60) cm long, 0.3–0.6 cm diameter, cylindrical to slightly complanate, green to wine-red to very dark castaneous, glabrous; peduncle bract 2.0–4.6 × 1.3–2.2 cm, shorter than the internode, ovate, acuminate, purplish-green, glabrous abaxially, subdensely brown-lepidote adaxially. Inflorescence (fertile part, excluding the petals) 15–27(–36) × 8–10 cm, simple or compound, with up to five suberect lateral branches; branches 6.5–16(–36) cm long × 4–6 cm wide (excluding the petals), 7–17(–20)-flowered, the distal one frequently aborted. Rachis 4–16(–23) × 0.2–0.5 cm in diameter, elliptic to quandrangular in cross section. Floral bracts 1.2–2.8 × (1.3–)2.2–2.6 cm, broadly ovate, acute, abaxially glabrous, adaxially subdensely brown-lepidote, ecarinate. Flowers distichous to secund, 4.1–4.8 cm long; sepals 2.0–3.1 × (0.6–)1.0–1.7 cm, elliptic, obtuse, yellow, sometimes purplish-yellow along the base, subdensely lepidote adaxially; petals 3.0–3.4 × 0.6–1.1 cm, ligulate, obtuse, erect to spreading, yellow; appendages (ligules) 0.7–0.9 × 0.2–0.3 cm, ligulate, apex obtuse, slightly asymmetric, free from the petals. Stamens exserted; filaments 30–33 × 1–1.4 mm, slightly complanate, greenish-yellow; anthers linear, ca. 6 × 1 mm, dorsifixed near the base; Pistil styles 3.0–3.2 cm, exserted, terete, yellowish-green; stigma ca. 1.5 mm in diameter, with convolute blade, yellow. Capsule 2–3 × ca. 0.7 cm, ovoidal. Seed ca. 0.6 cm long, brown; basal appendage ca. 0.6 cm long, beige.

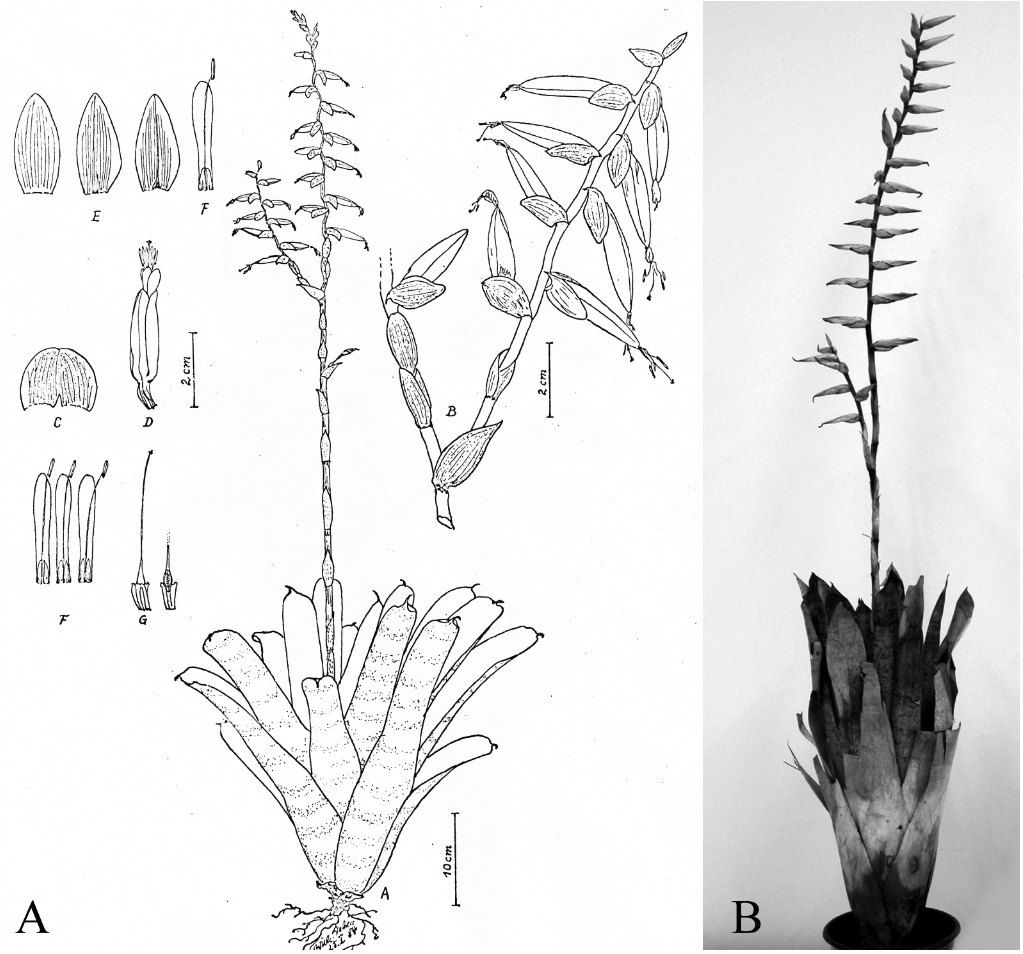

FIGURE 1. A. Original illustration of *Vriesea ouroensis* (from Weber 1986), copyright Wiley-VCH Verlag GmbH & Co. KGaA. Reproduced with permission. B. *Vriesea minarum* specimen collected along its type locality (*Versieux 140*), showing the same branch pattern as *V. ouroensis*.

Additional specimens examined:—BRAZIL. Without locality, *Sellow 70* (P). Minas Gerais: Mun. Brumadinho, Serra da Calçada, Retiro das Pedras, 20˚08’S, 44˚13’W, 1400 m, 1 January 1992, *Martens 687* (SPF); Mun. Caeté, Serra da Piedade, 19˚49’S, 43˚4’W, 945 m, 27 February 1986, *Braga et al. s.n.* (BHCB 7177, SPF); 3 February 1993, *Essenfelder 4* (MBM); 1800 m, 13 January 1971, *Irwin et al. 30248* (NY, UB, US); 1700 m, 9 October 1998, *Marques et al. s.n.* (BHCB 43760); 26 January 1999, *Marques s.n.* (BHCB 68512); 1800 m, 27 March 1957, *Pereira & Pabst 2678* (HB, RB, US); 1200 m, 23 March 1986, *Silva et al. CFCR-9736* (SPF, RB); 1600 m, 4 February 1997, *Vasconcelos & Oliveira s.n.* (BHCB 37881); Mun. Congonhas, em área de mineração, fl. in cult., 29 September 2003, *Carvalho s.n.* (BHZB 4017); Mun. Igarapé, pico Itatiaiuçu, 20˚7’S, 44˚20’W, 1361 m, 22 April 2008, *Carmo 2841* (BHCB); Mun. Itabirito, montanhas de minério de ferro, 800 m, 5 June 1976, *Martinelli & Gurken 917* (RB); formações rupestres do km 395 da rod. Rio-BH, 1000 m, 20 January 1978, *Martinelli 3608* (RB); pico do Itabirito, morro do galinheiro, 23 February 1994, *Teixeira s.n.* (BHCB 25147); Mun. Moeda, Marinho da Serra, 20˚19'S, 43˚56'W, 1540 m, 6 January 2006, *Carmo 466* (BHCB); 20˚20'S, 43˚56'W, 1544 m, 23 March 2008, *Carmo et al. 2751* (BHCB); serra da Moeda, 20 February 1990, *Grandi & Paula s.n.* (BHZB 1206); Mun. Nova Lima, Parque Estadual do Rola Moça, 20˚03'S, 44˚02'W, 1450 m, 1 April 2008, *Carmo 2807* (BHCB); 20˚02'41"S, 44˚00'04"W, 1430 m, 2 March 2009, *Carmo 4252* (BHCB); Mina de Capão Xavier, 13 March 2001, *Pimentel et al. 75* (BHCB); *Tameirão-Neto 3393* (BHCB, MBM); Mun. Ouro Branco, serra do Ouro Branco, 20˚28'S, 43˚41'W, 1200 m, 12 May 1990, *Arbo et al. 3978* (SPF); 19 September 1998, *Marques et al. s.n.* (BHCB 43373); 25 April 2001, *Paula et al. s.n.* (VIC 27452); 25 January 2002, *Paula s.n.* (VIC 27449, 27453); 25 February 2002, *Paula s.n.* (VIC 27448); 21 March 2002, *Paula et al. s.n.* (VIC 27446, 27447, 27450, 27451, 27454); Mun. Ouro Preto, 1050 m, 1982, *A. Seidel 929* (HAL); serra de Itatiaia, 10 September 2000, *Paula & Goldschmidt s.n.* (VIC 26459); Lavras Novas, 23 February 2002, *Silva et al. 8* (VIC); 25 January 1986, *Wagner et al. CFCR-9209* (BHCB, SPF); Mun. Rio Acima, serra de Gandarela, 20˚5'S, 43˚40'W, 1624 m, 11 October 2007, *Carmo & Vasconcelos 1192* (BHCB); Mun. Sabará, Mina do Segredão, 19˚50'S, 43˚46'W, 1200 m, 16 March 2008, *Mota et al. 3408* (BHCB); Pedra Rachada, 19˚53'S, 43˚48'W, 1600 m, 25 August 2003, *Versieux & Faria 140* (RFA); 19˚53'S, 43˚48'W, 1600 m, 9 May 2004, *Versieux et al. 176, 179, 180* (RFA); Mun. Santa Bárbara, serra de Gandarela, 20˚3'S, 43˚41'W, 1637 m, 20 October 2007, *Carmo 1238* (BHCB); serra de Gandarela/C2, 20˚3'24"S, 43˚41'28.6"W, 1637 m, 26 May 2008, *Carmo 3220* (BHCB); Caraça, 1400 m, June 1885, *Gounelle s.n.* (P 29 01/66).

Based on the examination of some selected specimens covering the different populations and morphological extremes (Appendix I), measurements were taken and are presented by means and standard deviations (Tab. 2, Fig. 3) and indicate a large uniformity for the selected morphometric traits analyzed.

TABLE 2. Morphological comparison of *Vriesea minarum* to other species within the complex by means and standard deviations (mean ± sd in cm).

	V. botafogensis (*N*=3)	*V. cacuminis* (*N*= 6)	*V. densiflora* (*N*= 2)	*V. minarum* (*N*=31)	*V. stricta* (*N*=16)
Flowering plant height	49.3 ± 2.1	33.7 ± 2.3	34.5 ± 0.7	52.5 ± 24.7	55.8 ± 27.5
Rosette high	22.7 ± 2.3	23.8 ± 1.9	30 ± 0.0	27.7 ± 14.4	33.5 ± 16.4
Blade length	13.3 ± 1.2	12.5 ± 1.5	13.5 ± 0.7	17.3 ± 6.8	18.1 ± 5.8
Blade width	3.3 ± 0.3	5.0 ± 0.9	5.9 ± 0.1	4.4 ± 0.9	6.1 ± 3.2
Sheath length	10.0 ± 1.0	9.0 ± 1.1	14 ± 1.4	10.8 ± 2.4	12.7 ± 3.8
Sheath width	6.5 ± 0.5	6.3 ± 0.8	6.9 ± 0.6	6.5 ± 1.6	8.2 ± 3.8
Peduncle diameter	0.3 ± 0.1	0.3 ± 0.1	0.4 ± 0.0	0.4 ± 0.1	0.5 ± 0.3
Peduncle bract length	3.2 ± 0.3	2.8 ± 0.5	1.9 ± 0.5	3.2 ± 1.0	3.0 ± 1.6
Floral bract length	1.8 ± 0.2	2.1 ± 0.3	1.3 ± 0.1	1.9 ± 0.3	2.1 ± 1.1
Floral bract width	1.2 ± 0.2	1.3 ± 0.2	1.5 ± 0.5	1.6 ± 0.2	1.7 ± 0.9
Sepals length	2.0 ± 0.3	2.3 ± 0.2	1.4 ± 0.1	2.6 ± 0.4	2.4 ± 1.2
Sepals width	0.7 ± 0.1	0.6 ± 0.1	0.7 ± 0.1	0.9 ± 0.2	0.9 ± 0.4

Discussion

Contrary to Weber's (1986) proposals, we hereby consider *V. minarum* as closely related to *V. stricta*. This relationship has been suggested by previous authors based on morphology (Leme 1999) and on anatomical features (Versieux *et al.* 2010a). Additionally, *V. minarum* is morphologically related to other yellow-flowered rupicolous *Vriesea* that also occur on isolated mountain tops, namely *V. cacuminis* Smith (1968: 79), occurring towards the south, and *V. densiflora* (occurring towards the north) (Fig. 2). There are some differences that can be easily observed between *V. minarum* and other species. *Vriesea minarum* differs from *V. stricta* in the shape of the inflorescence branches (more congested in *V. stricta* vs. simple or, if compound, branches are laxly arranged in *V. minarum*) and also by the flowers being more spaced in *V. minarum*. In the field the inflorescence branches of *V. stricta* frequently assume a castaneous coloration, but never become dark purplish as in *V. minarum* (Fig. 2 B, I). It is important to note that secund flowers do not separate these

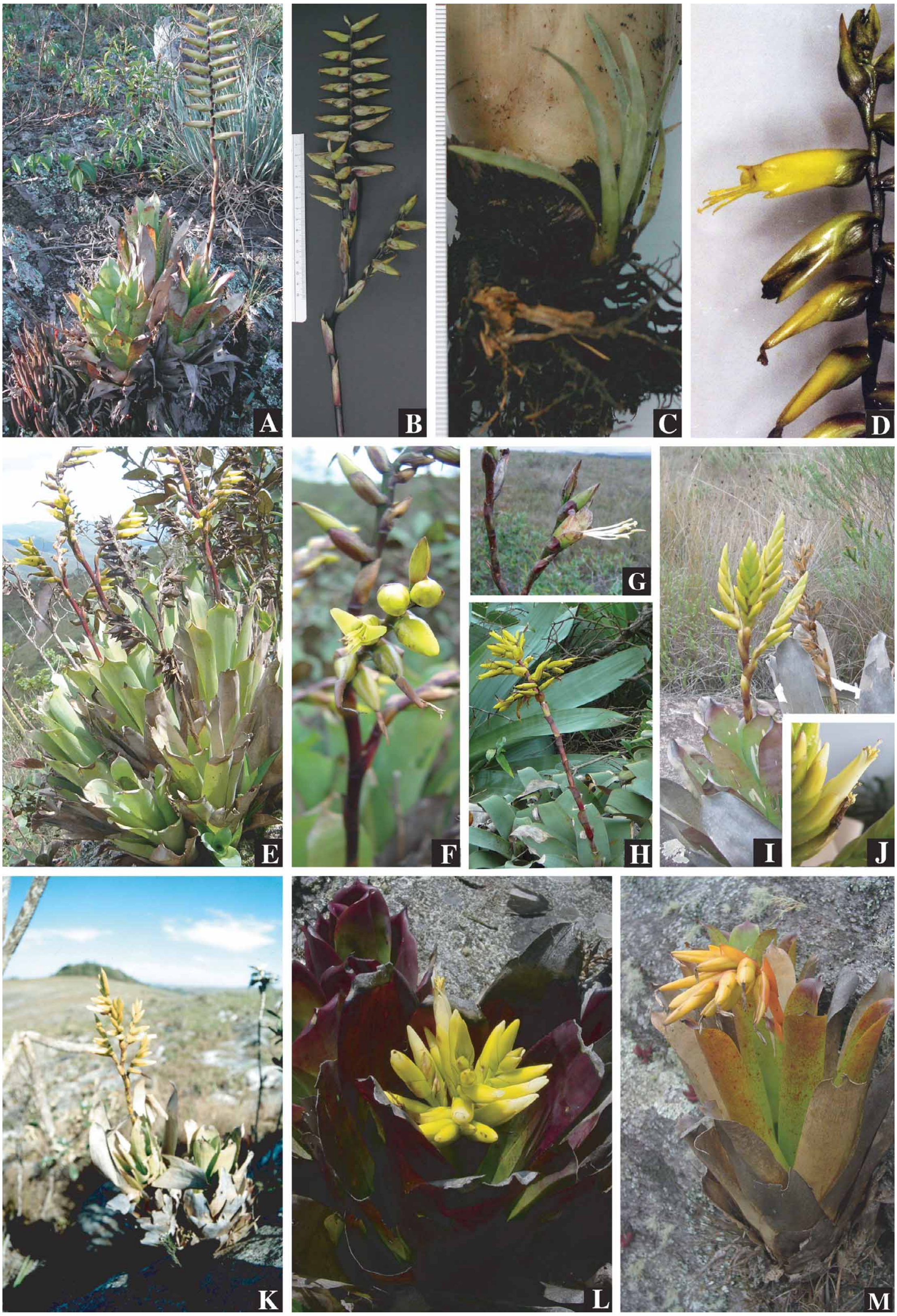

FIGURE 2. *Vriesea minarum* complex. A.–F. *Vriesea. minarum*. A. A clump of rosettes growing over iron rock. B. Detail of the inflorescence branches (scale = 15 cm). C. Asexual reproduction by basal shoot (scale in mm). D. Exserted stamens and stigma and one flower attacked by insects. E.–F. Clump of individuals from the Gandarela range showing slightly curved inflorescence branches and flowers with curved petals. G. *Vriesea atropurpurea* with long exserted stamens. H. *Vriesea botafogensis*. I.–K. *Vriesea stricta*. L. *Vriesea densiflora*. M. *Vriesea cacuminis*. Photos: L. Versieux, except: E.–F. (F.F. do Carmo), H. (L.J.T. Cardoso), and L. (P.L. Viana). Reproduced with permission.

two species. *Vriesea cacuminis* present inflorescence branches that are more densely arranged and its inflorescence is usually curved (Fig. 2 M) and all the peduncle bracts are imbricate, entirely covering the peduncle, and usually orange in colour. In *V. densiflora*, flowers are densely arranged forming a glomerule-like inflorescence and the sepals are narrower (Tab. 2). *Vriesea botafogensis* is the most distinct taxon, presenting a long peduncle with spreading to patent inflorescence branches concomitant with purple spotted leaves (Fig. 2 H). The specimens of *V. minarum* collected from the municipality of Santa Bárbara in the Gandarela range present rosettes more variable in size, and inflorescence branches and petal tips slightly curved (Fig. 2 E–F). Future molecular work may indicate whether these populations may represent a new subspecies, although the overall measurements taken from these specimens include them in the circumscription of *V. minarum* adopted here.

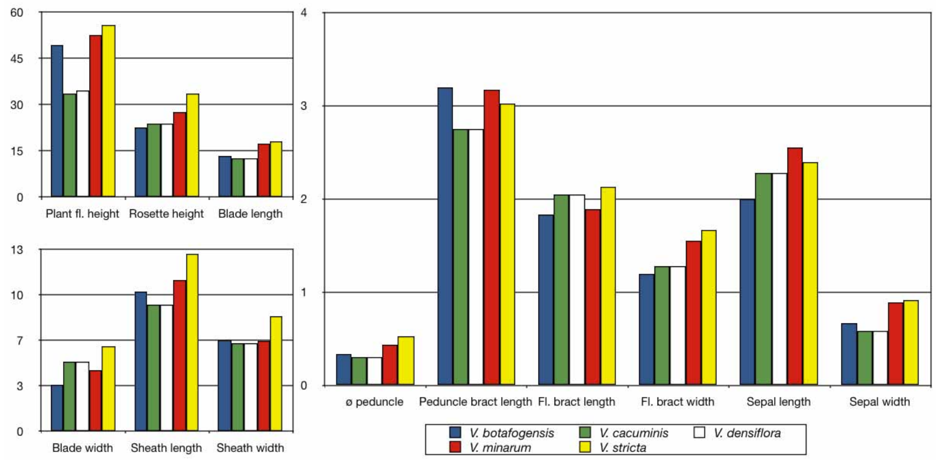

FIGURE 3. Mean values of measurements (all in centimetres) for some morphometric parameters of taxa treated here as part of the *Vriesea minarum* complex.

When we compare *V. minarum* and *V. ouroensis*, the differences observed between these two taxa (Fig. 1) probably arose from cultivation conditions. It is important to highlight that *V. ouroensis* was described from a single specimen cultivated by Brazilian nurseryman Alvim Seidel who sent it to Germany where it was described (Weber 1986). According to the protologue it was close to *V. neoglutinosa* Mez (1934: 636), but presenting orbicular floral bracts that were smaller than the sepals. *Vriesea ouroensis* was named after the municipality of Ouro, Minas Gerais, where it was first collected. However, there is no municipality named Ouro in this state. According to the collector of the type specimen it should be Ouro Preto (Alvim Seidel, personal communication, 2004), a municipality that is within the core area of occurrence of *V. minarum* (Fig. 4). After analyzing the protologue, the type material, the original illustration, and descendent plants (clones) from the one sent to Weber we concluded that *V. ouroensis* is a new synonym of *V. minarum*. Our observation in the greenhouse indicates that individuals collected at the type locality of *V. minarum* [*L.M. Versieux 140, 176, 180* (RFA)], soon change their tubular rosette form found in the field to a funnel-like, more open rosette, very similar to the illustration and photo provided by Weber that are annexed to the type specimen (Fig. 1). Most specimens of *V. minarum* examined in the field had persistent, dry older leaves creating a wrapper around the rosette and this characteristic is clearly shown in the original illustration of *V. minarum* (Smith 1943: t. 126). The coloration of the foliage and bracts is also extremely variable; in the wild habitat the leaves are usually wine red to purple in colour spotted along the margins and toward the apex. However, this coloration disappears on the younger leaves after some period of cultivation (personal observation). The peduncle and bracts also can be totally green or purplish-green until dark purple in colour (Fig. 2 B, D, F). Depending on the exposure to the sun, portions protected by bracts maintain a green coloration while exposed adjacent areas become purplish-red to purple. The sepal's colour varies from purplish-green to concolorous yellow.

Confusing *V. atropurpurea* and *V. minarum* is the most frequent mistake found in the identification of herbarium specimens. This issue has been treated by Leme (1999), Versieux & Wanderley (2008) and

Coffani-Nunes *et al.* (2010). Difficulty in separating these species started after Smith & Downs (1977) synonymized *V. minarum* under *V. atropurpurea,* but used the original illustration of the former species to depict the later one in *Flora Neotropica*. Their decision was probably motivated by the inexistence of a preserved type specimen and by the vague description provided by Silveira (1931) for *V. atropurpurea,* by the lack of additional collections and by the geographical proximity between the two type localities of these taxa (i.e., Serra do Cipó and Serra da Piedade). Nevertheless, *V. atropurpurea* is a crepuscular/night blooming species, which has a much taller inflorescence, reaching up to 1.7 m tall, long-exserted stamens, placing it in the section *Xiphion* (Coffani-Nunes *et al.* 2010). Furthermore, it does not grow over iron ore, but it prefers sandy soils.

Vriesea minarum was illustrated by Smith (1943), Weber (1986), and Leme (1999). References and ecological information on the related species of this complex may be found in Coffani-Nunes *et al.* (2010) for *V. atropurpurea*, Gouda (2006) and Monteiro & Forzza (2008) for *V. cacuminis*, Versieux (2008) and Versieux *et al.* (2010b) for *V. densiflora*, and Leme & Costa (1994) for *V. botafogensis.*

Distribution and ecology

Vriesea minarum is endemic to the IQ in MG (Versieux 2005, Versieux *et al.* 2008), occurring in 12 different municipalities, between 800–1800 m. It always grows rupicolous on a substrate that has been locally called '*canga*' or '*canga couraçada'* (Rizzini 1997). *Canga* is a superficial deposit blanketing other rocks composed of fragments of itabirite or high-grade hematite or other material cemented by limonite (Dorr 1965). A rich lithophytic community is usually found amidst this hard iron ore surface with some shallow crevices filled with rocky soils (Fig. 5). A few individuals of *V. minarum* may accidentally be seen growing over quartzite but only when close to larger populations on iron ore outcrops (F.F. Carmo, personal communication, 2010). Within the IQ, the species is rare and was missing from some floristic inventories in areas where it would be expected to occur (Mourão & Stehmann 2007, Coser *et al.* 2010). The occurrence of *V. minarum* in São Paulo state as listed by Mamede *et al.* (2007), should be considered a misidentification because the only specimen to which it refers to is treated as a new taxon without description by Costa *et al.* (2007). The one unchecked occurrence for the central Espinhaço range, next to the Serro municipality (Pifano *et al.* 2010) is based on a sterile specimen observed but not collected, making it difficult to verify whether it actually occurs there given the vegetative similarity among rupicolous *Vriesea* of this group.

Mapping the distribution of the species shows that there is a clear insular pattern for all of them (Fig. 4). *Vriesea atropurpurea* is the most restricted in area of occurrence. It grows only on sandy soils along the top of Serra do Cipó, but it is not morphologically similar in regard to the plant size, rosette and flower shapes to the remaining yellow-flowered *Vriesea* species treated here (Coffani-Nunes *et al.* 2010). *Vriesea stricta* also occurs at the summit of Serra do Cipó, but in the present work its range is extended onto Serra do Caraça, where it grows on the highest peaks. *Vriesea densiflora* occurs only as rupicolous on elevated areas of the Diamantina plateau and is the northernmost occurrence of the species complex. The recently described *Vriesea serranegrensis* (Leme in Leme & Kollmann 2011: 33) may extend this limit further north, as it is clearly related to *V. densiflora*. Within the IQ, *V. minarum* is the dominant species of yellow-flowered rupicolous *Vriesea*. Towards the south *V. cacuminis* occurs, which is restricted to the mountain ranges of Ibitipoca and Serra Negra. On inselbergs around the city of Rio de Janeiro one can find *V. botafogensis* (Leme & Costa 1994).

Phenology

Flowering individuals of *V. minarum* were observed from January to May, peaking from February to March. Fruits were collected from May to October. Field study conducted by Marques & Lemos-Filho (2008) on Serra da Piedade populations extends the floral bud and anthesis period to December. Wasps and hummingbirds visit the flowers (personal observation). Reproductive strategies of this species involve a strong clonal growth through the production of axillary or basal buds with new rosettes forming small clumps around the mother plant (Fig. 2 A, C, E). Also, there is an abundant production of wind dispersed seeds.

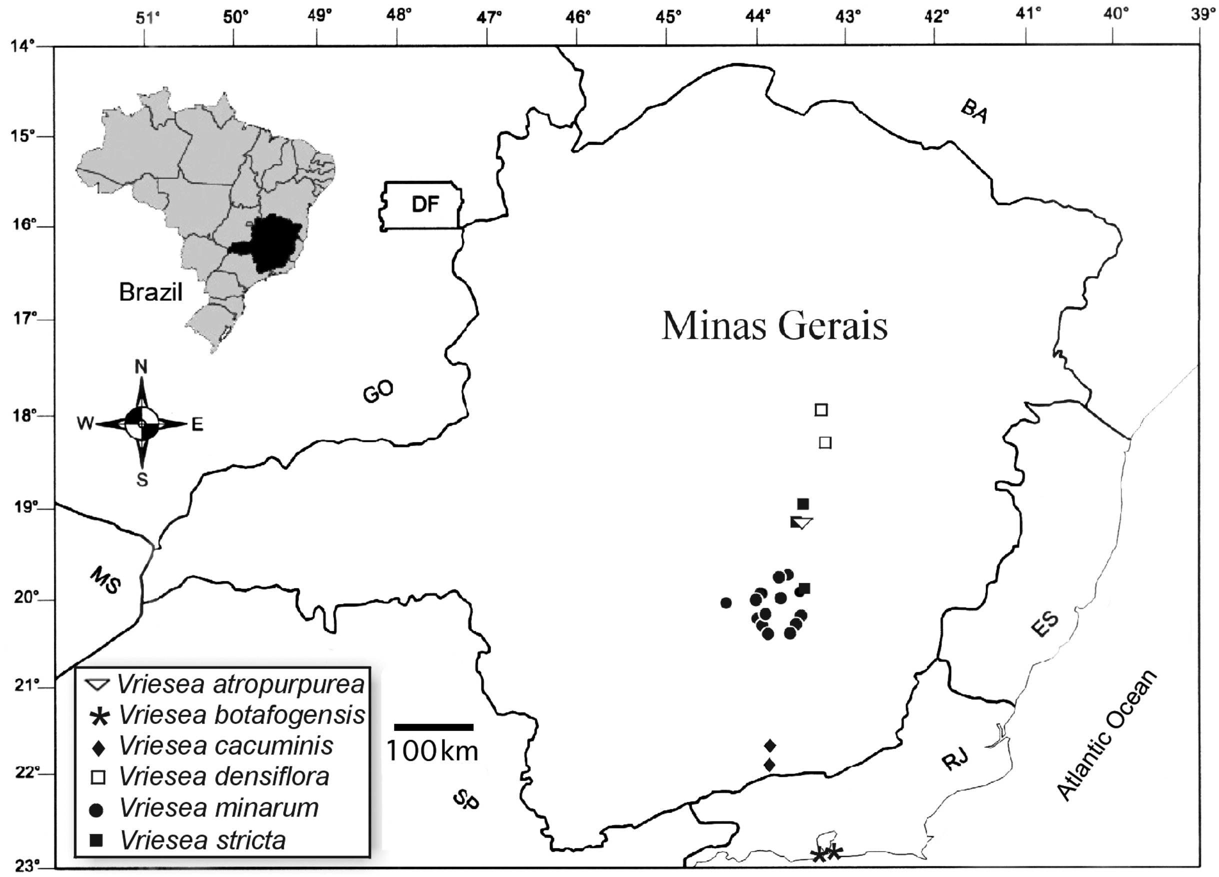

FIGURE 4. Map of distribution of taxa treated here as part of the *Vriesea minarum* complex.

Conservation

Systematic and taxonomic knowledge are essential to conserve biological diversity (Cotterill 1995). Different studies have been conducted discussing the effects of taxonomic changes or species delimitation on setting targets for conservation (May 1990, Morrison III *et al.* 2009). Parochial taxonomy as well as taxonomic exaggeration (Knapp 2002, Pillon & Chase 2007) may tangle determination of species thus delaying conservation acts or causing difficulties in the dialogue between taxon specialists and conservation agencies. Here we could observe that the difficulties in identifying and determining the area of occurrence of *V. minarum* are possible causes for this species being less protected than it should be. The case of *V. ouroensis*, that had its type specimen lost for several years (Dr. Uwe Braun, personal communication 2004; Versieux & Wendt 2006) and indicated an erroneous collection locality, draws attention to a practice that still survives today, particularly with ornamental and collectable plants such as bromeliads, orchids and cacti. Some botanists, horticulturists and collectors should pay more attention to carefully prepare descriptions of new taxa of the Brazilian flora. Provenance data is essential to discuss biogeography as well as to establish conservation practices and reserves. Also, type specimens should be carefully prepared and stored (McNeill *et al.* 2006) and, ideally, at least isotypes should be kept in Brazilian herbaria. In taxonomic and especially horticultural literature it is not uncommon to find cases of new species that were described from cuttings or seeds obtained from nurseries, allegedly collected in Brazil, generating doubts about the origin and resulting in taxonomical or biogeographical misleading conclusions that may undermine conservation of species in the long term.

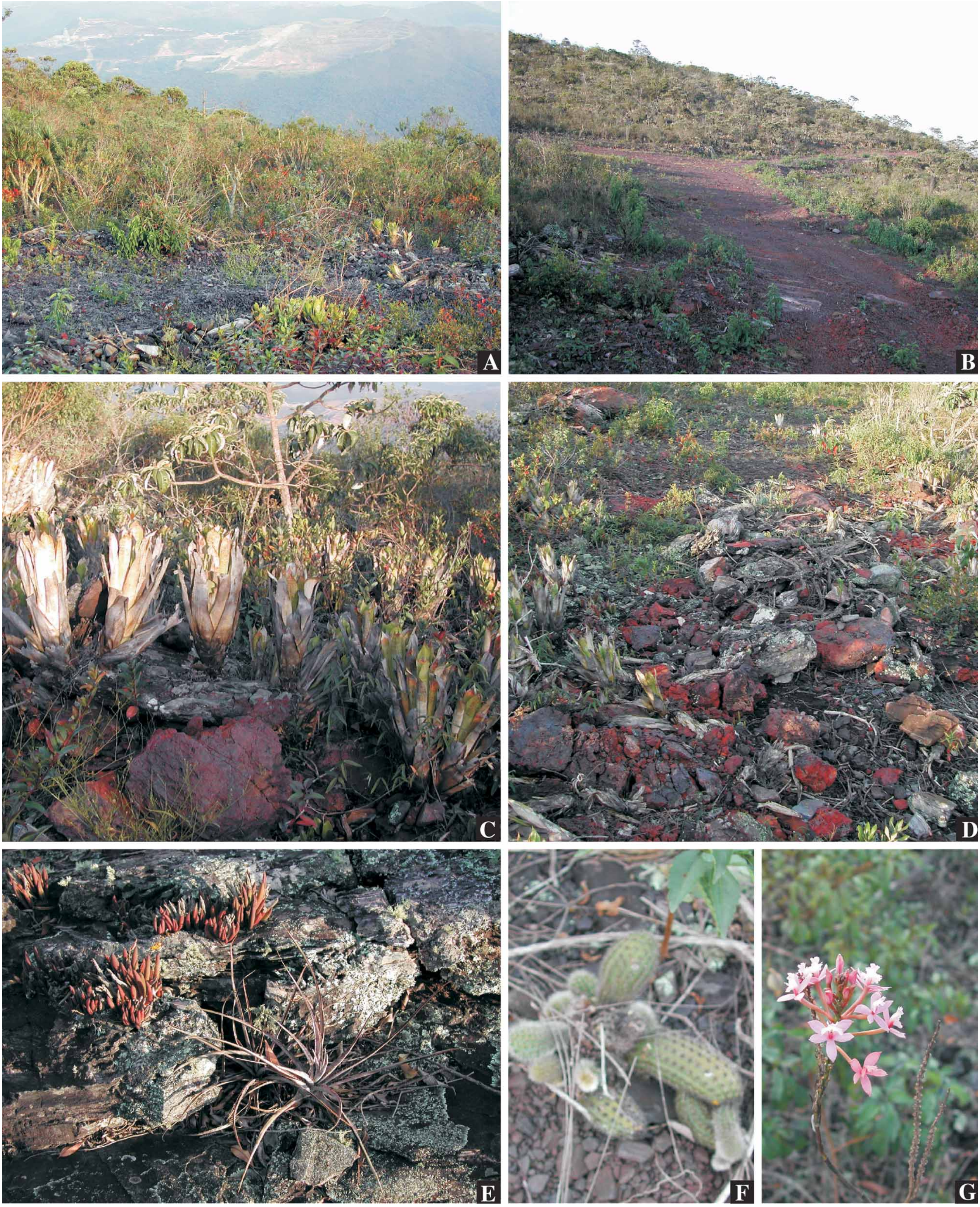

FIGURE 5. Habitat and habitat loss of *Vriesea minarum* in the IQ, Sabará, close to Serra da Piedade, Minas Gerais. A. Clearing of the characteristic shrubby vegetation of iron rocky soil (in the foreground) and the destruction caused by iron ore and gold mining (second plan). B. Opening of a road to prospect iron ore over an area previously occupied by *Vriesea minarum*. C. *Vriesea minarum* growing directly over the iron ore *canga* carapaces. D. Destruction of a population after mining prospecting. E.–G. Native plants that also occur on iron rocky outcrops from the IQ. E. *Cryptanthus schwackeanus* and *Acianthera teres* (Lindley) Borba (2003: 23) F. *Arthrocereus glaziovii* G. *Epidendrum saxatile* Lindley (1841: 84) along its type locality region.

During the process of extracting iron ore, the substrate on which *V. minarum* grows is the first to be removed generating a great impact on the habitat for this species. The greatest problem for the preservation of the *V. minarum* populations is the progressive destruction of their habitats that do not survive above the economic pressure to exploit iron and gold ores. Historic herbarium specimens collected along the Caraça range are testimony that the species has been progressively loosing its area of occurrence. A single specimen collected at the Serra do Curral, Nova Lima, in 1934 by Mello-Barreto that was cited by Smith (1971) is the last record of the occurrence of this species along this heavily mined mountain range. No recent collection from this locality was recorded here. In the same way, other narrowly ranged species that usually co-occur with populations of *V. minarum*, such as *Arthrocereus glaziovii* (Schumann) Taylor & Zappi (1991: 85, Cactaceae) and other rupicolous species of Bromeliaceae, such as *Cryptanthus schwackeanus* Mez (1891: 203), *Dyckia consimilis* Mez (1894: 479), *D. simulans* Smith (1943: 108), *D. schwackeana* Mez (1894: 478), *Vriesea longistaminea* Paula & Leme (Leme & Paula 2004: 25) and some Orchidaceae, like several *Hoffmannseggella* species (Verola *et al.* 2007) also suffer from the same habitat destruction. Endemism for metallophytes has been reported for other regions of the globe and different ore-rich substrates (Faucon *et al.* 2010). The iron ore outcrop vegetation of Brazil is still not well studied, and this particular environment presents significant variations regarding the flora and fauna composition, especially along an elevational gradient (Lopes *et al.* 2000, Jacobi *et al*. 2007). Not only is *Vriesea minarum* under threat but in addition the unique environment full of endemic plants and animals is being brutally removed without concern for conservation, just for quick financial gain. The restricted distribution of the populations of *V. minarum*, the occurrence only inside a few protected areas, and the rapid loss of habitat led Versieux (2005) and Versieux & Wendt (2007) to categorize this species as endangered (EN) following the IUCN criteria. Knowledge that its distribution is restricted to the IQ is clearly indicated in earlier references (Versieux 2005, Versieux & Wendt 2006, 2007, Versieux *et al.* 2008). Surprisingly, this species appears categorised only as data deficient in the Brazilian official plant red list (Ministério do Meio Ambiente 2008). It is not difficult to understand that there may be a conflict of interest among mining companies operating in the IQ and local environmentalists, especially if one notes that most of the specimens examined above came from prime mining areas. If the environmental agencies accept that *V. minarum* is actually under threat and include it under official protection, several measures regarding the conservation of this taxon will have to be taken prior to providing permits to open new mines, and delaying the advance of economic activities in the region. Other similar examples in the Brazilian red list involve rupicolous species of Bromeliaceae and *Arthrocereus glaziovii,* a cactus also endemic to the IQ, that were also previously treated as EN (Taylor & Zappi 2004) but later listed only as data deficient (Ministério do Meio Ambiente 2008).

Here, we sustain the evaluation of *V. minarum* as EN according to the following IUCN (2001) criteria: extent of occurrence estimated to be less than 5000 km^2; continuing decline observed, inferred or projected in area, extent and/or quality of habitat; and extreme fluctuations in number of locations or subpopulations (B1biii, ciii). Through the present herbaria review it is possible to register the occurrence of the species in only one state reserve: Parque Estadual do Rola Moça in Nova Lima. Nevertheless, even within this reserve there are known cases of illegal collecting and other risks that cause threat to the conservation of *V. minarum* (Biodiversitas 2007). It is important to highlight that many of these plants after being extracted from the wild by untrained collectors, are severely damaged and kept under unsuitable conditions and are sold in local flower markets and along the streets of Belo Horizonte, together with rupicolous orchids (personal observations). Nevertheless, a serious *ex-situ* cultivation program involving compromised growers or collectors and local botanic gardens should be encouraged and seems to be a good alternative for conserving a large number of genotypes of this species. The type locality (Serra da Piedade, Caeté) is a Catholic Sanctuary, but not an official state reserve, and the area suffers from visitors who collect orchids, bromeliads, and lichens for Christmas decorations (personal observations). There are records from a private reserve in Ouro Branco, but there the species is naturally rare (Braga 2008). The occurrence in Serra do Caraça (which is also a private reserve) has no support from recent observations or collections, although this area has been the subject of a detailed inventory. Other areas where several collections were obtained (e.g. Pico do Itatiauçu, Serra do Gandarela, Serra da Pedra Rachada in Sabará, and Serra da Moeda) are not under legal protection and their populations are exposed to different risks, particularly the expansion of adjacent mining areas. It is extremely desirable that a conservation unit be established along the eastern border of the IQ, particularly protecting the distinct population occurring at the Gandarela range. This would increase the number of areas where *V. minarum* could be minimally conserved to four, encompassing all the borders of the IQ.

Recently, an increase in the opening of new mines has been recorded in most areas of the IQ (Jacobi & Carmo 2008). It is important to highlight that the IQ occupies an area of almost 7,000 km^2, of which only 100 km^2 are iron rock outcrops (Jacobi *et al.* 2007, Jacobi & Carmo 2008). Given these numbers it is clear how habitat-restricted *V. minarum* is. Since their habitat is being transformed very quickly, we recommend *in-situ* and *ex-situ* conservation. Studies of population genetics and micro propagation will be needed and living collections should be made from populations when concession to a mine is given and destruction of the populations are inevitable. Monitoring systems of the populations in the field should be refined. Conservation of pristine IQ iron rock metallophytes communities will ensure not only the survival of *V. minarum* but that of a great number of other species. *Ex-situ* conservation is also desirable beneficial to preserve the genetic variation, despite its requirements for new investigations aimed at ecosystem restoration through the transplanting of individuals and the moving of undisturbed topsoil. Versieux (2005) suggested testing the potential of *V. minarum* in the ecological restoration of abandoned mining areas, which would be a much-appreciated effort.

Conclusions

The effective conservation of plant species depends upon a well-defined taxonomical basis as well as an updated knowledge of species distribution. In this work the circumscription of *V. minarum* was redefined, including the dubious *V. ouroensis* as a new synonym. Descriptions of new taxa should take into account the accuracy of provenance data, quality and accessibility of the type material, and the avoidance of parochial taxonomy/taxonomical exaggeration, since all these practices may undermine conservation. The extent of the occurrence and the area of occupancy of *V. minarum* are progressively diminishing and this is attested here by historical collections and fieldwork. As recently described by Jacobi *et al*. (2011), Brazil faces a great dilemma: the preservation of its rich metalliferous flora versus the increasing economic pressure of ores demand. The availability of good scientific collections, accurate taxonomical and distributional data will be essential to address more sustainable practices and conservation priorities for the future of endemic species, such as *Vriesea minarum*.

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Appendix 1: List of specimens examined for each species followed by measurements (in centimetres).

Species	Herb.	Collector	Flowering plant height	Rosette height	Blade length	Blade width	Sheath length	Sheath width	Diam. pedunc.	Length pedunc. Bract	Length fl bract	Width fl bract	Sepal length	Sepal width
	BHCB	*Sousa s.n. (BHCB 13727)*	34	22	12	5.6	8.2	6.8	0.3	3.1	1.8	1	2	0.4
	RB	*Giordano 2434*	32	22	14	4	8	5	0.2	3	2.5	1.3	2.5	0.6
V. cacuminis	RB	*Krieger 9298*	34	25	12	4	10	6	0.3	2.1	2.3	1.3	2.4	0.7
	RB	*Martinelli 15307*	38	27	13	5.6	10	6	0.3	3.1	1.7	1.1	2.4	0.5
	RB	*Monteiro 1*	32	23	14	6	8	7	0.3	3	2	1.5	2.4	0.8
	RB	*Sucre 7267*	32	24	10	4.5	10	7	0.4	2.2	2	1.5	2	0.5
N = 6		***mean=***	***33.7***	***23.8***	***12.5***	***5.0***	***9.0***	***6.3***	***0.3***	***2.8***	***2.1***	***1.3***	***2.3***	***0.6***
		standard deviation=	*2.3*	*1.9*	*1.5*	*0.9*	*1.1*	*0.8*	*0.1*	*0.5*	*0.3*	*0.2*	*0.2*	*0.1*
	BHCB	*Arruda 94*	55	31	17	5.7	9	6.7	0.4	3.5	2	1.4	2.5	1.2
	BHCB	*Carmo 1238*	45	29	12.6	4.3	10	6.6	0.5	2.7	1.7	1.8	2.1	0.8
	BHCB	*Carmo (BHCB 125808)*	?	?	10	4.6	9.5	6.5	0.4	2.6	2	1.8	2.1	1
	BHCB	*Carmo 2751*	38	19	9	2.5	6	4.2	0.2	2.7	1.7	1.9	2.7	0.9
	BHCB	*Carmo 2841*	45	?	12	3	15.6	6.5	0.4	3.5	1.7	1.6	2.3	0.9
	BHCB	*Carmo 3220*	?	?	22.5	4.5	13.5	7	0.4	2.6	1.6	1.4	2.2	0.6
	BHCB	*Carmo 4252*	37	?	10	3.6	9.5	5.3	0.2	3	2.4	1.7	3	0.9
	BHCB	*Carmo 4342*	?	?	11	3.5	9	5.5	0.4	2.5	1.3	1.1	2	0.7
	BHCB	*Carmo 446*	34	19	9	3.2	7	4.2	0.4	2.7	2.1	1.6	2.8	1.1
	BHCB	*Marques s.n.*	?	?	15	5.5	12	8	0.4	2.6	2.1	1.3	2.7	1.1
	BHCB	*Mota 3408*	78	34	19	5	15	9	0.5	4.4	1.6	1.4	3.2	0.9
	BHCB	*Tameirão-Neto 3393*	44	25	14	4.9	10	8	0.4	2.9	1.8	1.3	2.8	0.7
	BHCB	*Vasconcelos (BHCB 37881)*	?	?	10	3.6	11	5.9	0.5	3.2	1.3	1.2	2.1	0.7
	NY	*Irwin 30248*	55	23	15	4.6	10	6	0.6	2	1.5	2	2.6	0.9
	RB	*Alves 1517*	?	25	13	4.7	12.5	?	?	3.2	2	1.4	2.1	0.9
V. minarum	RB	*Braga 2210*	64	28	13	5	12	6.7	0.5	4.2	2.6	1.7	2.4	0.8
	RB	*Martinelli 3608*	54	34	18	5	13	7	0.3	2.3	2	1.7	2.7	0.8
	RB	*Martinelli 917*	64	31	19	4.5	13	6.5	0.5	2.8	2	1.3	2.3	0.9
	RB	*Pereira 2678*	35	19	9.5	4	9	4.7	0.3	2	1.5	1.2	2.4	0.6
	RFA	*Calvente 99*	48	?	20.5	3.8	10	5.7	0.45	4.1	2.2	1.4	3	1
	RFA	*Versieux 140*	58	?	25	4.5	12	6.5	0.5	3.3	2	1.8	2.8	0.7
	RFA	*Versieux 176*	70	32	18.7	5.5	10.5	7.4	0.45	4.4	2	1.4	2.5	0.8
	RFA	*Versieux 179*	70	?	18	4.5	12	6.6	0.55	4.2	2.1	1.4	2.8	0.9
	RFA	*Versieux 180*	42.5	?	18	4.6	11	6.8	0.4	3.6	2.2	1.6	2.65	0.9
	RFA	*Versieux 205*	?	?	15	4.5	6	4.6	0.55	2.9	1.8	1.3	2.9	0.9
	SPF	*Arbo 3978*	56	26	27.5	5.9	12	7.2	0.5	2.9	1.7	1.8	2.45	1
	SPF	*Braga 7177*	48	29	27.5	4.5	11	6.5	0.45	2.1	1.6	1.6	2.4	1
	SPF	*Mello Silva CFCR9736*	68	35	29	4.7	10	6.5	0.45	3.3	1.6	1.8	2	0.8
	SPF	*SPF 87251*	60	36	37	2.5	15	7.5	0.7	7	2.7	1.9	3.2	1.2
	SPF	*Wagner CFCR9209*	42	21	20	5.5	10	7	0.4	2.7	2.1	1.8	3.1	1
	SPF	*Wagner CFCR9209*	49	30	23	3	9	7	0.4	2.4	1.8	1.6	2.35	0.9
N = 31		***mean=***	***52.5***	***27.7***	***17.3***	***4.4***	***10.8***	***6.5***	***0.4***	***3.2***	***1.9***	***1.6***	***2.6***	***0.9***
		standard deviation=	*24.7*	*14.4*	*6.8*	*0.9*	*2.4*	*1.6*	*0.1*	*1.0*	*0.3*	*0.2*	*0.4*	*0.2*
	BHCB	*Mendes 121*	66	33	17	5,5	14	8.5	0.6	2.8	2	1.7	2.1	0.7
	BHCB	*Vasconcelos (BHCB 52555)*	37	?	14	5,2	12	7,7	0,4	2.8	2,5	1,8	2,3	0,9
	BHCB	*Vasconcelos (BHCB 52562)*	?	?	?	?	?	?	0,5	2.7	2.5	1.9	2.3	0.9
	BHCB	*Vasconcelos (BHCB 53707)*	?	?	14	5.1	10.5	7	0.4	2.5	2.5	2.3	2.3	1
	RB	*Costa 44-b*	63	33	22	6	14.5	8.5	0.6	2.5	2.1	1.4	2.5	0.7
	RB	*Duarte 2105*	53	37	23	7	18	9	0.6	3.5	2	1.2	2.5	0.6
	RB	*Martinelli 4264*	35	29	18	7.5	14	10	0.5	3.2	2.2	1.5	2.5	1.2
V. stricta	SP	*Hensold CFSC7731*	75	42	26	6	13	10	0.7	3,5	2	1.5	3	0.9
	SP	*Joly CFSC3681*	40	32	14	6	12	6.5	0.4	3.2	2,1	1.8	2.2	1
	SP	*Versieux 258*	?	?	21	5,5	14	9	0,6	2,7	2,1	1,8	2,2	1
	SP	*Versieux 301*	47	32	17	6	10	8	0,5	2,4	2	1,6	2,5	1
	SP	*Wanderley 1976*	?	?	18	6,8	11	8	0,6	3,7	2,1	1,6	2,1	0,9
	SP	*Wanderley 216*	58	27	16	4,5	10	7	0.4	2,4	2	1.7	2.2	1
	SP	*Wanderley 217*	62	36	13	6	14	7,5	0,7	4	2,1	1,2	2,5	0,8
	SP	*Wanderley 219*	73	38	21	5	13	7	0,7	4,2	2,3	1,6	2,4	0,8
	SP	*Wanderley CFSC5554*	60	30	18	6,5	10	?	0,5	2,4	2	1,6	2,2	1
N = 16		***mean=***	***55.8***	***33.5***	***18.1***	***6.1***	***12.7***	***8.2***	***0.5***	***3.0***	***2.1***	***1.7***	***2.4***	***0.9***
		standard deviation=	*27.5*	*16.4*	*5.8*	*3.2*	*3.8*	*3.8*	*0.3*	*1.6*	*1.1*	*0.9*	*1.2*	*0.4*
	RB	*Leme s.n.*	50	20	14	3	10	6	0.3	3.5	1.9	1	2.3	0.6
V. botafogensis	RB	*Sucre 10905*	51	24	14	3.5	9	6.5	0.3	3.1	1.6	1.3	1.9	0.6
	RB	*Cardoso 139*	47	24	12	3.5	11	7	0.4	3	2	1.3	1.8	0.8
N = 3		***mean=***	***49.3***	***22.7***	***13.3***	***3.3***	***10.0***	***6.5***	***0.3***	***3.2***	***1.8***	***1.2***	***2.0***	***0.7***
		standard deviation=	*2.1*	*2.3*	*1.2*	*0.3*	*1.0*	*0.5*	*0.1*	*0.3*	*0.2*	*0.2*	*0.3*	*0.1*
V. densiflora	BHCB	*Wanderley 2581*	35	30	14	5.8	13	6.4	0.35	2.2	1.3	1.8	1.5	0.7
	BHCB	*Viana 1519*	34	30	13	6	15	7.3	0.4	1.5	1.2	1.1	1.3	0.6
N = 2		***mean=***	***34.5***	***30.0***	***13.5***	***5.9***	***14.0***	***6.9***	***0.4***	***1.9***	***1.3***	***1.5***	***1.4***	***0.7***
		standard deviation=	*0.7*	*0.0*	*0.7*	*0.1*	*1.4*	*0.6*	*0.0*	*0.5*	*0.1*	*0.5*	*0.1*	*0.1*