

# Disentangling the identity of the only naturalized alien *Viola* (Violaceae) species in Switzerland

Antoine Jousson<sup>1\*</sup>, Philippe Juillerat<sup>2</sup>, Michael Jutzi<sup>3</sup>, Laura Torriani<sup>1</sup> and Brigitte Marazzi<sup>1,4</sup>

<sup>1</sup> InfoFlora, c/o Museo cantonale di storia naturale, Viale C. Cattaneo 4, 6900 Lugano, Switzerland

<sup>2</sup> InfoFlora, c/o Conservatoire et Jardin botaniques, Chemin de l'Impératrice 1, 1292 Chambésy, Switzerland

<sup>3</sup> InfoFlora, c/o Botanischer Garten, Altenbergrain 21, 3013 Bern, Switzerland

<sup>4</sup> Museo cantonale di storia naturale, Viale C. Cattaneo 4, 6900 Lugano, Switzerland

\* [antoine.jousson@infoflora.ch](mailto:antoine.jousson@infoflora.ch)

**Abstract:** The only wild-growing alien *Viola* (Violaceae) in Switzerland is a perennial ornamental species native from North America and established mainly in the lowlands of Southern Swiss Alps. Although plants are known as *V. cucullata* Aiton in the Swiss flora, they actually do not fit to the original description of this species. In this exploratory study, we thus aimed at clarifying their taxonomic identity by field investigating all populations found in the Maggia Valley, i.e., the region with most reported occurrences. We documented six populations *in situ* with photographs, fixed plant material in ethanol and collected herbarium specimens. For determination, we used identification keys from two very recent systematic publications on American violets. Specimens were keyed out as *V. sororia* var. *sororia*, and more precisely, the white cultivar *V. sororia* 'Albiflora'. Furthermore, other cultivars like 'Freckles' and 'Priceana' seem to exist in Switzerland, and introgression of other species, such as *V. communis*, cannot be ruled out. Genetic studies comparing European with American populations could provide further evidence supporting taxonomic conclusions.

**Keywords:** common blue violet, cultivar, ornamental species, subsection *Boreliamericanae*, taxonomy, *Viola cucullata*, *Viola sororia*

**Delucidazioni sull'identità dell'unica specie aliena naturalizzata di *Viola* (Violaceae) in Svizzera**

## RIASSUNTO ESTESO

**Introduzione:** L'unica viola esotica naturalizzata in Svizzera è una specie ornamentale perenne originaria del Nord America. Sebbene le piante siano note come *Viola cucullata* Aiton nella flora svizzera, in realtà non rientrano nella descrizione effettiva di questa specie. La sua distribuzione sembra essere limitata quasi esclusivamente al sud delle Alpi svizzere, mentre nelle opere floristiche dei paesi limitrofi non è riportata. Nel Cantone Ticino, in particolare in Vallemaggia, vi sono numerose osservazioni di questa viola finora denominata *V. cucullata*. Il fatto che *V. cucullata* in Italia sia considerata un'identificazione erronea e che le piante al sud delle Alpi svizzere si trovino in ambienti molto diversi da quelli del suo areale di origine ha sollevato dubbi sull'identità di questo taxon in Svizzera, motivo che ci ha spinti a chiarirne l'identità tassonomica attraverso questo studio.

**Materiali e metodi:** A questo proposito, nel 2023 abbiamo condotto un lavoro sul campo in Vallemaggia sulle piante segnalate nella banca dati nazionale di InfoFlora come *V. cucullata*. Questa valle comprende circa un terzo di tutte le segnalazioni del Cantone Ticino. Sei siti sono stati visitati in maggio durante la fioritura e in settembre per raccogliere i semi. Le diverse popolazioni sono state documentate attraverso delle indagini in loco, scattando delle fotografie e raccogliendo dei campioni d'erbario. In un secondo momento, i campioni sono stati determinati attraverso le due chiavi d'identificazione delle viole americane più recenti, cioè quelle di Ballard et al. (2023) e Weakley et al. (2023).

**Risultati:** Al sud delle Alpi svizzere il taxon è presente lungo i bordi delle strade, lungo i margini delle foreste, nei prati e nei vigneti estensivi. Una popolazione è stata considerata come casuale, perché appena fuori da un giardino, tre popolazioni sono state considerate come subspontanee perché vicine ai giardini, e due come naturalizzate, perché lontane dai giardini. Quest'ultime sono state trovate in prati da sfalcio, suggerendo la capacità del taxon di stabilirsi e disperdersi da solo. Sulla base delle due chiavi d'identificazione, l'identità di questa viola è risultata essere più correttamente attribuita a *V. sororia sensu stricto*, parente stretta di *V. cucullata* e anch'essa del Nord America, e più precisamente alla cultivar bianca *V. sororia* 'Albiflora'. Questa cultivar sembra essere la più diffusa nel Cantone Ticino e in Svizzera in generale, ma le fotografie allegate ad alcune segnalazioni presenti nella banca dati InfoFlora indicano che in natura potrebbero esistere anche altre cultivar ornamentali di *V. sororia* come 'Freckles' e 'Priceana'.

**Discussione:** Anche se non si può escludere che la vera *V. cucullata* sia stata importata in Europa e persino in Svizzera, è improbabile che si presenti in natura a causa delle sue particolari esigenze ecologiche. Interpretare le caratteristiche diagnostiche e quindi l'identificazione delle specie di questo complesso gruppo di *Viola* rappresenta spesso una sfida. Nel nostro caso, alcune caratteristiche non corrispondono pienamente a quelle di *V. sororia sensu stricto* descritta in Nord America. Queste leggere discrepanze potrebbero essere spiegate da introgressioni di altre specie nordamericane come *V. communis*. Infatti,

*V. communis* e *V. sororia* possono ibridarsi naturalmente nel loro areale di origine e anche artificialmente per scopi orticoli. Gli individui osservati al sud delle Alpi svizzere e che presentano caratteristiche sovrapposte potrebbero quindi essere il risultato di una variazione intraspecifica o di un'ibridazione per scopi orticoli.

**Conclusioni:** L'indagine eseguita al sud delle Alpi per identificare l'identità della viola neofita ha mostrato che assegnare nomi a piante ornamentali naturalizzate può essere complicato. Si tratta di un problema noto e comune in tutto il mondo. Poiché i tratti diagnostici non corrispondono completamente a quelli di *V. sororia sensu stricto* delle chiavi dicotomiche nord-americane, è possibile che le piante studiate presentino un certo grado di introgressione, ad esempio con la glabra e strettamente imparentata *V. communis*. Studi genetici che paragonano le popolazioni europee con quelle americane potrebbero fornire ulteriori prove a sostegno delle conclusioni tassonomiche.

**Parole chiave:** cultivar, specie ornamentali, subsection *Borealiamericanae*, tassonomia, *Viola cucullata*, viola sorella, *Viola sororia*

## INTRODUCTION

Cultivation of exotic species in beautiful gardens and parks has always been an important touristic attraction in southern Switzerland (Schoenenberger et al. 2014). Characterized by the Insubric climate with sunny and dry winters and sunny but stormy summers (Spinedi & Isotta 2004), Canton Ticino is well known for its rich exotic wild flora (Schoenenberger et al. 2014), which includes a wide range of escaped garden species, and new ones are constantly discovered (e.g., Mangili et al. 2020; Marazzi et al. 2021, 2022). Among garden escapes there are iconic plants, like the palm *Trachycarpus fortunei*, that visibly give an exotic touch to the local vegetation (Tonello et al. 2022). In contrast, smaller alien plants are often overlooked, even though attractive. A small and white-flowered *Viola* species – focus of this study – is such an example.

Violaceae is a medium-sized plant family containing over 1'000 species (Wahlert et al. 2014). The three largest traditional genera, *Hybanthus*, *Rinorea* and *Viola* include more than 90% of the family's species (Tokuoaka 2008), and *Viola* is the largest and most widely distributed with ca. 660 species occurring worldwide in temperate regions and tropical mountain areas (Wahlert et al. 2014). Due to their colorful flowers, *Viola* species have long been appreciated ornamentals, both natives and aliens (Russell 1957; Carvalho et al. 2023). In Europe, up to seven alien violets have been deliberately introduced for ornamental purposes (Raab-Straube & Henning 2018). In Switzerland, 28 taxa belonging to the family Violaceae are found in the wild (Juillerat et al. 2017): 26 are native, one is an archeophyte (i.e., introduced before 1500 A.D.), and only one is a neophyte (i.e., an alien species introduced after 1500 A.D.), namely the North American *V. cucullata* Aiton (Lauber et al. 2018). Interestingly, the alien distribution of this species appears to be limited almost exclusively to southern Switzerland (InfoFlora 2023), as it is not reported in the floras of neighboring countries (Fisher et al. 2008 and Flora Österreichs 2024, for Austria; Galasso et al. 2024 for Italy; Hand et al. 2024 for Germany) except in France (Tela Botanica 2024). In Italy, this taxon is actually considered as a misidentification, based on erroneous reports that resulted to be *V. sororia* Willd., another North American alien species (Galasso et al. 2018, 2024). The two species are phylogenetically closely related, as they both

belong to *Viola* subsection *Borealiamericanae* (Marcussen et al. 2022; Ballard et al. 2023; Weakley et al. 2023). In contrast to *V. cucullata*, *V. sororia* appears to occur as a garden escape in several European countries. Indeed, it is reported in more detail from Austria (Fischer & Karrer 2005), Bosnia and Herzegovina (Maslo et al. 2018), Hungary (Balogh et al. 2004), Poland (Pliszko 2015), Slovakia (Mereda et al. 2008), Slovenia (Hroneš & Kobrlová 2013) and Ukraine (Shynder et al. 2023). Furthermore, according to Hess et al. (1970) and the Flora Helvetica (Lauber et al. 2018), *V. cucullata* occurs in well-drained or fairly humid habitats, in meadows, in open woodlands and along roadsides. However, in its native range, it typically grows in wet habitats, such as marshes (Little & McKinney 2015; Maslo et al. 2018; Ballard et al. 2023).

In southern Swiss Alps, the oldest herbarium specimen of *V. cucullata* known to us was collected in 1948 in Sorengo (Dübi Herbarium in the herbarium of the Natural History Museum of the Canton Ticino, LUG). In 1950 a specimen reported as an escape was collected on the Brissago Islands, most probably derived from cultivated plants of the botanical garden that had just been opened to the public on the main island (Dübi Herbarium in LUG). The taxon was later reported as escaped and wild growing by Hess et al. (1970). These authors and other botanists as well (e.g., Christophe Bornand, pers. comm. 2012, and Andreas Huber and Werner Lehmann, pers. comm. 2018, both in InfoFlora 2023) already expressed doubts about the accuracy of the taxonomy for this taxon. This uncertainty and the fact that *V. cucullata* has been considered a misidentification in Italy and that plants in southern Switzerland occur in habitats significantly different than those in its native range raised doubts about the identity of the “Swiss” taxon. Therefore, the main goal in the present exploratory study was to clarify the taxonomic identity of the plants that had so far been named *V. cucullata* in Switzerland, and more particularly, to explore whether *V. sororia* could be a more suitable taxon.

## MATERIALS AND METHODS

To discriminate among native and alien *Viola* species in the field and provide a morphological description, we followed two very recent comprehensive taxonomic studies on North American violets by using their iden-

tification key to “acaulescent violets lacking stolons, with blue or violet to purple flowers” in Ballard et al. (2023; key G, p. 29) and the key to “acaulescent violets lacking stolons, with unlobed leaves” in Weakley et al. (2023; key E, p. 965).

Fieldwork focused on sites of *V. cucullata* in the lowlands of the Maggia Valley. This valley includes about a third of all reports with this name in Canton Ticino (98 in Switzerland, 92 in the Southern Swiss Alps, 83 in Canton Ticino, 25 in Maggia Valley; InfoFlora 2023). A total of six sites (one population per site; Tab. 1) were visited on 5.5.2023 to document the taxon while flowering and on 29.9.2023 to collect seeds. At each site, the habitat was documented, the degree of establishment of the population (casual, subspontaneous or established) was hypothesized based on the distance from gardens where plants were cultivated, living plants were photographed *in situ*, plant material was fixed in 70% ethanol for long-term conservation of flowers, and representative individuals were collected as herbarium specimens. For each population, voucher specimens (three to five individuals) and respective ethanol samples (three to five individuals) were deposited at LUG herbarium. In addition, photographs attached to 40 of the 98 available *V. cucullata* reports from the InfoFlora database (InfoFlora 2023) and a total of 14 herbarium specimens named *V. cucullata* from the LUG herbarium were examined visually to identify similarities with field-collected specimens from this study.

## RESULTS

All studied populations consisted of individuals growing very close one another and often still connected through their rhizomes (clonal propagation). One population was considered as casual, because just off a garden, three populations were considered as subspontaneous (i.e., intermediate between casual and established) because close to gardens (less than 10 m distance), and two as established because far away from gardens (over 100 m distance; Tab. 1). They grew in

anthropogenic environments, especially in (semi-)natural habitats near gardens, like roadsides, hay meadows, extensive vineyards and forest margins (Fig. 1). Populations on roadsides and forest edges (near gardens; Fig. 1A) appeared subspontaneous as relatively near to the cultivated mother plants. In contrast, those found in meadows, more distant from gardens, appeared established (Fig. 1B-E; see established populations of Coglio and Maggia).

The key traits from Ballard et al. (2023) and Weakley et al. (2023) used for identification are listed in Table 2 and illustrated in Figure 2. All studied specimens from the six sites were morphologically highly similar, as described in the following. All had large rhizomes on which floral buds were already developed at the time of field work (Fig. 2A-B). Leaves (and foliage) ovate to reniform with an acute apex (Fig. 2A-B), sparsely to densely hirsute, especially on the petioles and on the lower surface of leaf blades (Fig. 2A-C). Pedicels slightly hirsute with small trichomes on the apex (Fig. 2G). Sepals slightly and shortly ciliate at their base (Fig. 2G), the lowest ones oblong to ovate with an obtuse to rounded apex. Auricles of sepals not prominent, but short (1-2 mm) and slightly rounded (Fig. 2F-H). Petals white with deep blue-purple veins (nectar guides) at their base and more pronounced on the spurred petal (Fig. 2D). Throat pale greenish-yellow (Fig. 2D). No hairs occurred on the spurred petal (absence of hairiness; Fig. 2D-E), but those on lateral petals were filiform to slightly tubular at the apex (Fig. 2E). Fruits were capsules, ellipsoidal, glabrous, uniform in color, and up to 1 cm long (Fig. 2I-J). Seeds displayed a short caruncle and were up to 2 mm long (Fig. 2K).

## DISCUSSION

The recent taxonomic treatments by Ballard et al. (2023) and Weakley et al. (2023) providing keys and diagnostic details missing from previously available literature on North American violets proved crucial to clarify the identity of a white-flowering alien violet occurring in southern Switzerland and ascribed so far to

Table 1: Sampling sites of the alien *Viola* taxon in the Maggia Valley (Canton Ticino).

CH1903+ coordinates	Municipalities (locality)	Habitats	Establishment	Altitude [m a.s.l.]	Specimina visa
2°700'966, 1°117'431	Avegno-Gordevio (Avegno di Fuori)	Forest edge	Subspontaneous	279	LUG 20978
2°700'437, 1°120'410	Avegno-Gordevio (Gordevio)	Roadside	Subspontaneous	315	LUG 20979
2°697'347, 1°122'679	Maggia (Maggia)	Meadow	Established	340	LUG 20974
2°696'475, 1°122'686	Maggia (Moghegno)	Forest edge	Subspontaneous	391	LUG 20977
2°695'914, 1°125'220	Maggia (Coglio)	Meadow	Casual	355	LUG 20976
2°695'637, 1°125'211	Maggia (Giumaglio)	Meadow	Established	342	LUG 20975



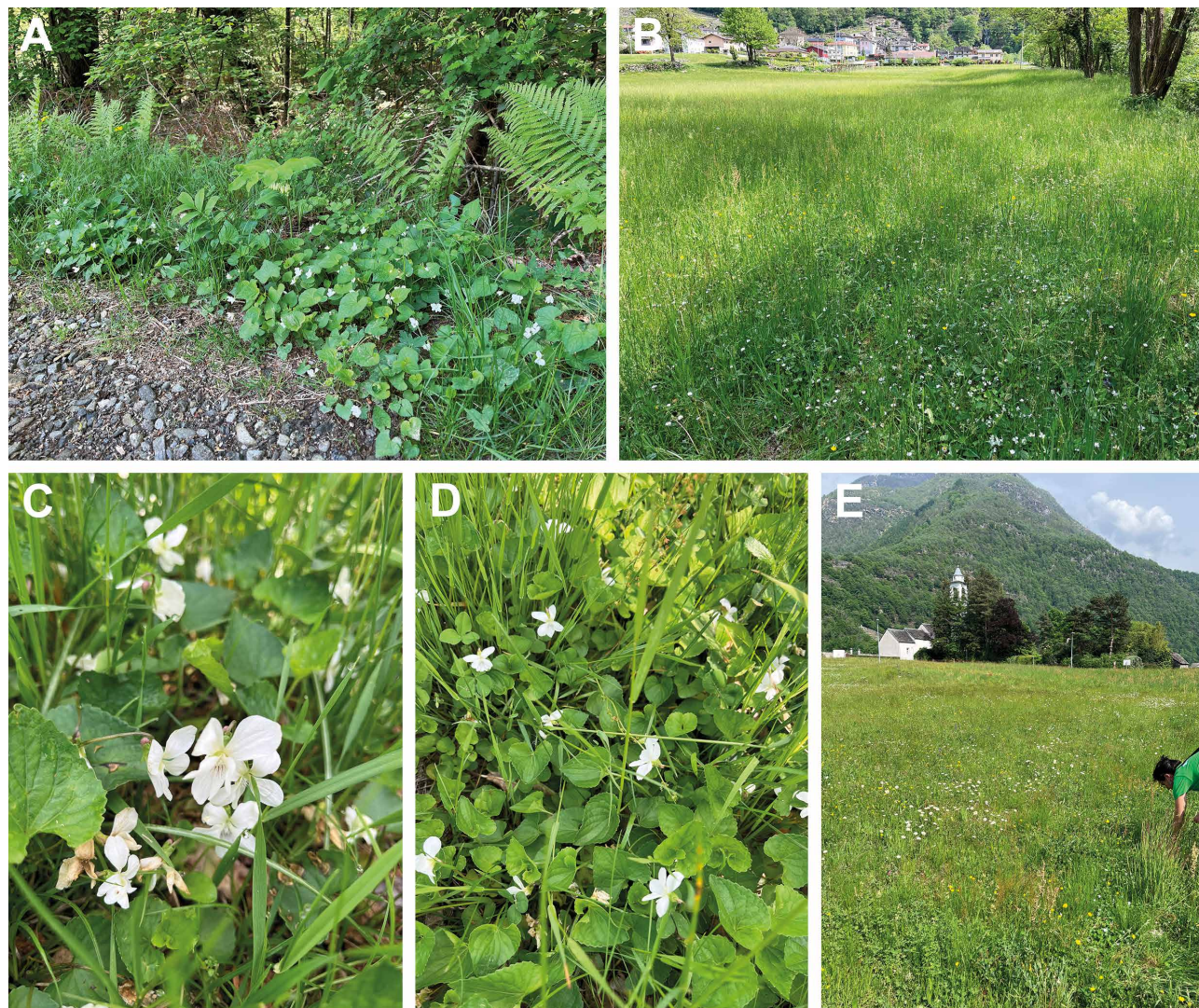


Figure 1: Habitats and sites in which *Viola sororia* ‘Albiflora’ occurs in southern Switzerland (Maggia Valley, Canton Ticino). A: Forest margin (Moghegno). B-C: Meadow (Giumaglio). D-E: Meadow (Maggia).

the North American *V. cucullata*. In the following, we discuss the traits that allowed identification of the collected plant material to a single taxonomic entity and the challenges of such identification.

### Diagnostic traits and identification challenges

The main result of our identification is that field collected individuals from the Maggia Valley cannot be attributed to *V. cucullata*. The traits that are diagnostic to the violet group including *V. cucullata* concern the form and shape of auricles and sepals. Indeed, in all studied specimens, observed auricles were not prominent (*versus* prominent, rectangular, and entire in *V. cucullata*), and the lowest sepals were oblong to ovate (*versus* linear-lanceolate, acuminate from near base to narrowly sharply acute apex as in *V. cucullata*). Furthermore, there is a difference in habitat requirements: in North America, *V. cucullata* is found in marshes, swamps, lakeshores, stream- or riverbanks, and ditches (Ballard et al. 2023), which is not the case for the locations of our field-collected specimens nor any other examined database records and herbarium specimens from southern Switzerland. Although we cannot exclude that the true *V. cucullata* has been imported to Europe and even Switzerland, its specialized habitat

requirements make an escape and establishing in such habitats rather unlikely.

Observed traits and habitat preferences best fitted another taxon within *Viola* subsection *Borealiamericanae*, namely a member of the *V. sororia* species complex (Ballard et al. 2023, pp. 37 and 215; Weakley et al. 2023, p. 966). In its native range, *V. sororia* grows in dry to mesic habitats in woods, thickets, stream banks, moist prairies, pastures, disturbed ground, but not in saturated soil (McKinney & Russell 2002; Little & McKinney 2015). In its introduced range, the species occurs in similar habitats: along roadsides, in meadows and along forest edges, but principally near gardens in urban areas (Maslo et al. 2018; Shnyder et al. 2023), as also observed in this study. In southern Switzerland, the taxon can be considered established, as some populations occur far from gardens (Fig. 1). The spread dynamic is nevertheless slow, given that Hess et al. (1970) already referred to it as naturalized in 1970.

The *V. sororia* complex includes *V. sororia sensu stricto* and two variants, the so-called “glabrous” and “hirsutuloides” (or “hirsutula-like”) variants (Ballard et al. 2023; Weakley et al. 2023). Within this complex, we lean more towards *V. sororia sensu stricto* (Ballard et al. 2023, which corresponds to *V. sororia* var. *sororia* in Weakley



et al. 2023), especially because the foliage of our specimens is clearly hirsute and the calix is slightly ciliate at the base and practically never completely eciliate (i.e. lacking cilia), and in particular to the white cultivar *V. sororia* ‘Albiflora’ (McKinney & Russell 2002), because of corolla color. Therefore, in Switzerland, records of the InfoFlora database (InfoFlora 2023) with the name *V. cucullata* could be misidentified *V. sororia* ‘Albiflora’ plants. This cultivar appears to be the most widespread in southern Switzerland, but photographs attached to some of the InfoFlora database records indicate that other escaped *V. sororia* cultivars, such as ‘Freckles’ and ‘Priceana’, may also exist (InfoFlora 2023; Fig. 3).

*Viola sororia* is polymorphic, especially with respect to petal color, which is why it is difficult to distinguish it in the field (Cullen et al. 1997; Hroneš & Koblrova 2013; Ballard et al. 2023). In Europe, several morphologically distinct cultivars are found in gardens, and three of them, ‘Albiflora’, ‘Freckles’ and ‘Priceana’ are known to be naturalized, especially in Eastern Europe (in Slovenia: Hroneš & Koblrova 2013; in Bosnia and Herzegovina: Maslo et al. 2018; and in Ukraine: Shnyder et al. 2023). Cultivar ‘Albiflora’ is characterized by white petals with prominent deep purple veins on the spurred petal (Fig. 3B), ‘Freckles’ is characterized by white petals with deep blue-purple spots (Fig. 3C), and

‘Priceana’ has white petals with long blue-deep purple veins similar to ‘Albiflora’ but on all petals (Fig. 3D). Interestingly, ‘Priceana’ was previously considered as a taxonomic entity and not a man-made cultivar. For instance, in North America, it was first described at the species rank as *V. priceana* Pollard, then interpreted at the infraspecific form rank as *V. sororia* f. *priceana* by Cooperrider (1984), who justified his choice as follows (p. 167): “since the plant occurs sporadically and unpredictably in nature, the rank of form is the most appropriate for this plant”. Successively, traded plants of this taxon in Europe are named as a cultivar instead of a form. Recently, Ballard et al. (2023, p. 75) proposed a different combination for *V. priceana* by assigning it to another closely related species, namely *V. communis* f. *priceana*, because they consider flowers of this form almost identical to those of *V. communis* f. *communis*, but just “a bit larger, perhaps a pleiotropic effect of the partial albinism”.

In the identification keys (Ballard et al. 2023; Weakley et al. 2023), two diagnostic traits are used to discriminate *V. communis* from *V. sororia*: the form of lowest sepals and that of auricles. The lowest sepals are “oblong to ovate, obtuse to rounded” in *V. sororia*, whereas they are “lance- to ovate-triangular” in *V. communis*; the auricles are considered “not prominent” in *V. sororia*,

Table 2: Key traits to discriminate *V. cucullata* from *V. communis* and *V. sororia* var. *sororia*. Based on Ballard et al. (2023) and Weakley et al. (2023).

	<i>Viola cucullata</i> <sup>1</sup>	<i>Viola communis</i> <sup>1</sup>	<i>Viola sororia</i>	
			<i>V. sororia</i> var. <i>sororia</i> <sup>1</sup> ( <i>V. sororia</i> s. str.)	<i>V. sororia</i> cv. <i>Albiflora</i> <sup>2</sup>
<b>Biological type</b>	Perennial rhizomatous	Perennial rhizomatous	Perennial rhizomatous	Perennial rhizomatous
<b>Leaves</b>	Upper leaf blade surface with scattered easily visible appressed hairs	Glabrous or upper leaf blade surface with scattered minute appressed hairs	Sparsely to densely hirsute (see also <i>V. sororia</i> complex for “glabrous” and “hirsutula-like” variants)	Sparsely to densely hirsute (especially on the lower surface of leaf blades)
<b>Peduncle</b>	Glabrous to pubescent	Glabrous	Moderately hirsute	Slightly hirsute
<b>Sepals</b>	Linear-lanceolate, acuminate	Ovate-triangular, acuminate	Oblong to ovate, ciliate at the base	Oblong to ovate, slightly ciliate at the base
<b>Sepal auricles</b>	Commonly prominent and rectangular	Weakly prominent, trapezoidal, erose	Short and rounded or truncate	Short and rounded or truncate
<b>Petals</b>	Corolla violet with contrasting dark purple eyespot around throat	Corolla purple (white with contrasting purple-gray eyespot around the throat in <i>V. communis</i> f. <i>priceana</i> )	Corolla blue to purple, throat white	Corolla white with blue-purple veins situated at the very base and more marked on the spurred petal (cv. <i>Albiflora</i> ) <sup>3</sup>
<b>Petal hairs</b>	Strongly clavate to reniform	Filiform or slightly clavate	Filiform or slightly clavate	Filiform to slightly tubular at the summit
<b>Habitats</b>	Wet soils	Floodplains, upland/lowland transitions	Dry to mesic habitats in woods, thickets, stream banks, moist prairies	(Semi-)natural zones near gardens, roadsides, meadows, forest edges
<b>Hybrids</b>	With both species (see p. 78 in Ballard et al. 2023)	Natural hybridization and plant breeding for ornamental purposes (see also <i>V. domestica</i> E.P. Bicknell; see p. 82 in Ballard et al. 2023)		

<sup>1</sup> Adapted from the determination keys of Ballard et al. (2023) and Weakley et al. (2023).

<sup>2</sup> Traits observed in this study, in plants from six sites in southern Switzerland.

<sup>3</sup> Other cultivars of the *V. sororia* complex occur in Switzerland with petals varying in color (e.g., ‘Freckles’ and ‘Priceana’). See also InfoFlora database (InfoFlora 2023) and McKinney & Russell (2002).

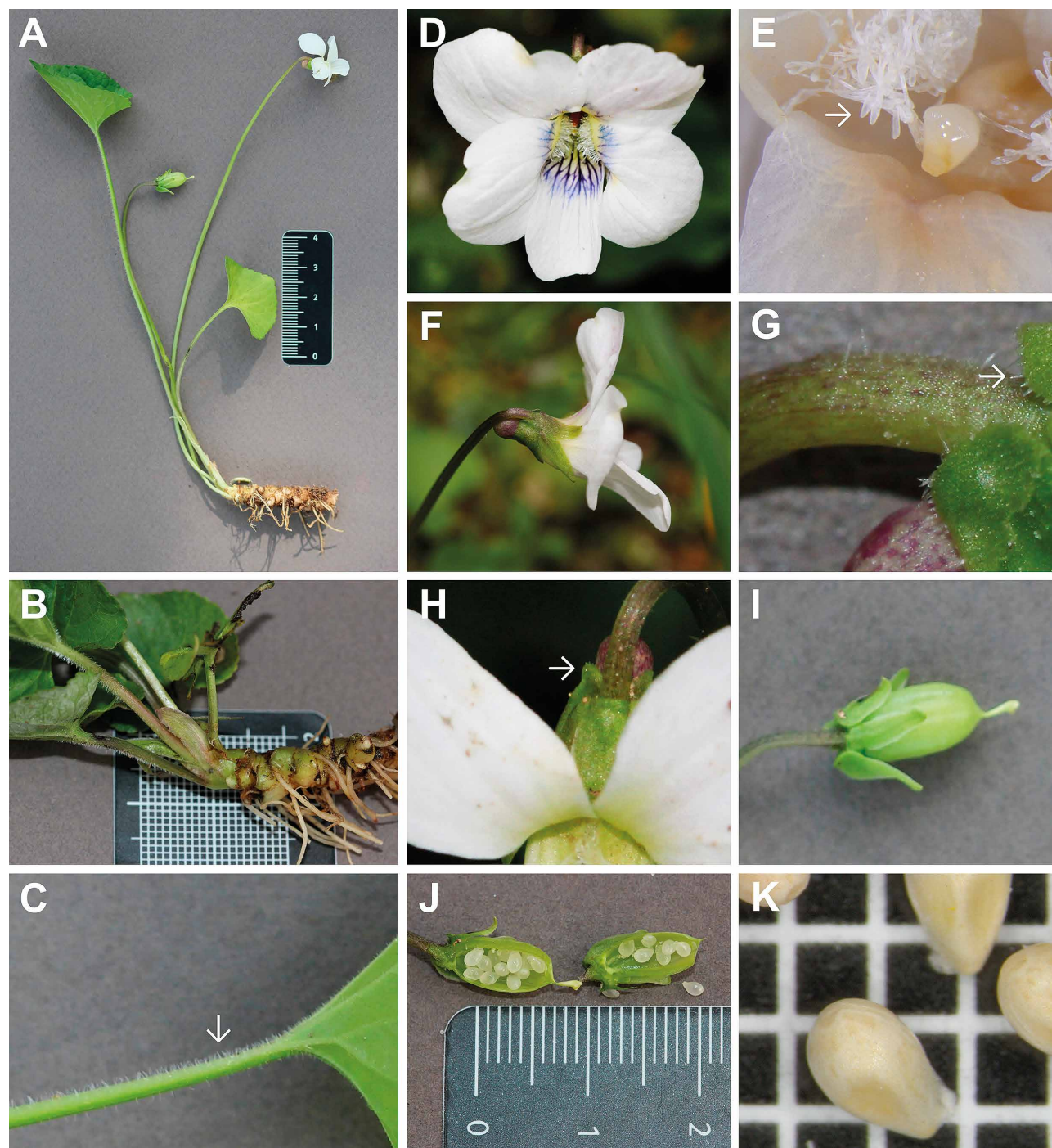


Figure 2: Morphology of *Viola sororia* ‘Albiflora’ in southern Switzerland (Maggia Valley, Canton Ticino). A: Entire plant morphology. B: Base of the plant with stipules, rhizomes and rhizome buds. C: Hirsute petiole and lower surface of leaf blades (arrow points to hairs). D: Flower (general front view). E: Details of hairs (arrow points to hairs that are filiform to slightly tubular at the summit). F: Flower, general lateral view. G: Details of the base of sepals (arrow points to the hairy trichomes). H: Calyx, upper view (arrow points to the small and rounded auricles). I: Capsule. J: Capsules and non-mature seeds. K: Details of seeds, on a 1mm-grid.

whereas they are “weakly prominent” in *V. communis* (Weakley et al. 2023, p. 966). However, overlaps in the discriminating options (e.g. lowest sepals ovate) or different interpretations of “weakly prominent” can make identification challenging. Individuals displaying overlapping characteristics could be the result of intra-specific variation or hybridization.

#### Possible hybridization and plant breeding

*Viola sororia* is a polymorphic species known to easily hybridize with other closely related species (McKinney & Russell 2002; Ballard et al. 2023; Weakley et

al. 2023). Indeed, according to Ballard et al. (2023), *V. communis* and *V. sororia* can hybridize naturally in their native range and have also been artificially hybridized for horticultural purposes. For instance, they consider that many of the morphological features observed in the closely related *V. domestica* E.P. Bicknell appear intermediate between or shared by either *V. communis* or *V. sororia*. Therefore, they conclude that *V. domestica* is almost undoubtedly a cultigen of plant breeders (Ballard et al. 2023, p. 82). In our case, we cannot completely exclude that our studied plants be the result of hybridization or be subjected to introgression. Indeed,



pilosity at the calyx base observed in the studied plants does not fully match that of *V. sororia sensu stricto*, as it is not as clearly ciliate as expected according to Ballard et al. (2023). This slight mismatch could be explained by introgressions of the glabrous species *V. communis*.

## CONCLUSIONS

By investigating the identity of an alien violet in southern Switzerland, our study shows that assigning names to escaped ornamentals can be complicated. This is actually a known and common problem worldwide (Hawkes 1986). Reasons can be the multiple introductions of taxa that are morphologically very similar, the use of inappropriate names, or the lack of comprehensive taxonomic treatments in the native range leading to name confusion once the species is introduced in Europe (Hawkes 1986; Pyšek et al. 2004; Hulme & Weser 2011). In Europe, and in Switzerland as well, in addition to *Viola*, other genera that include commonly cultivated ornamental species, such as *Cornus* (Xiang et al. 2006), *Cotoneaster* (Dickoré & Kasperek 2010), and *Opuntia* (Desfayes 2008) pose major nomenclatural and identification problems to taxonomists that have to give a scientific name to taxa that have escaped from

gardens. Fortunately, for the alien *Viola* taxon of our study, very recent comprehensive taxonomic work (Ballard et al. 2023; Weakley et al. 2023) including detailed identification keys proved crucial and made it possible to disentangle its identity. In sum, in southern Switzerland, alien *Viola* that are currently named *V. cucullata* can most likely be ascribed to *V. sororia* var. *sororia*, especially cultivar ‘Albiflora’, and a few to ‘Freckles’ and ‘Priceana’. Individuals that correspond to the cultivar *V. sororia* ‘Priceana’ should be named *V. communis* f. *priceana* according to Ballard et al. (2023). If this combination is accepted, it would mean that not one but two alien *Viola* species are recognized in Switzerland. Because diagnostic traits do not completely match those of *V. sororia sensu stricto*, it is possible that studied plants could display at least some degree of introgression, for example, of the glabrous and closely related *V. communis*. Genetic studies comparing European and American populations could provide key information to support our taxonomic conclusions.

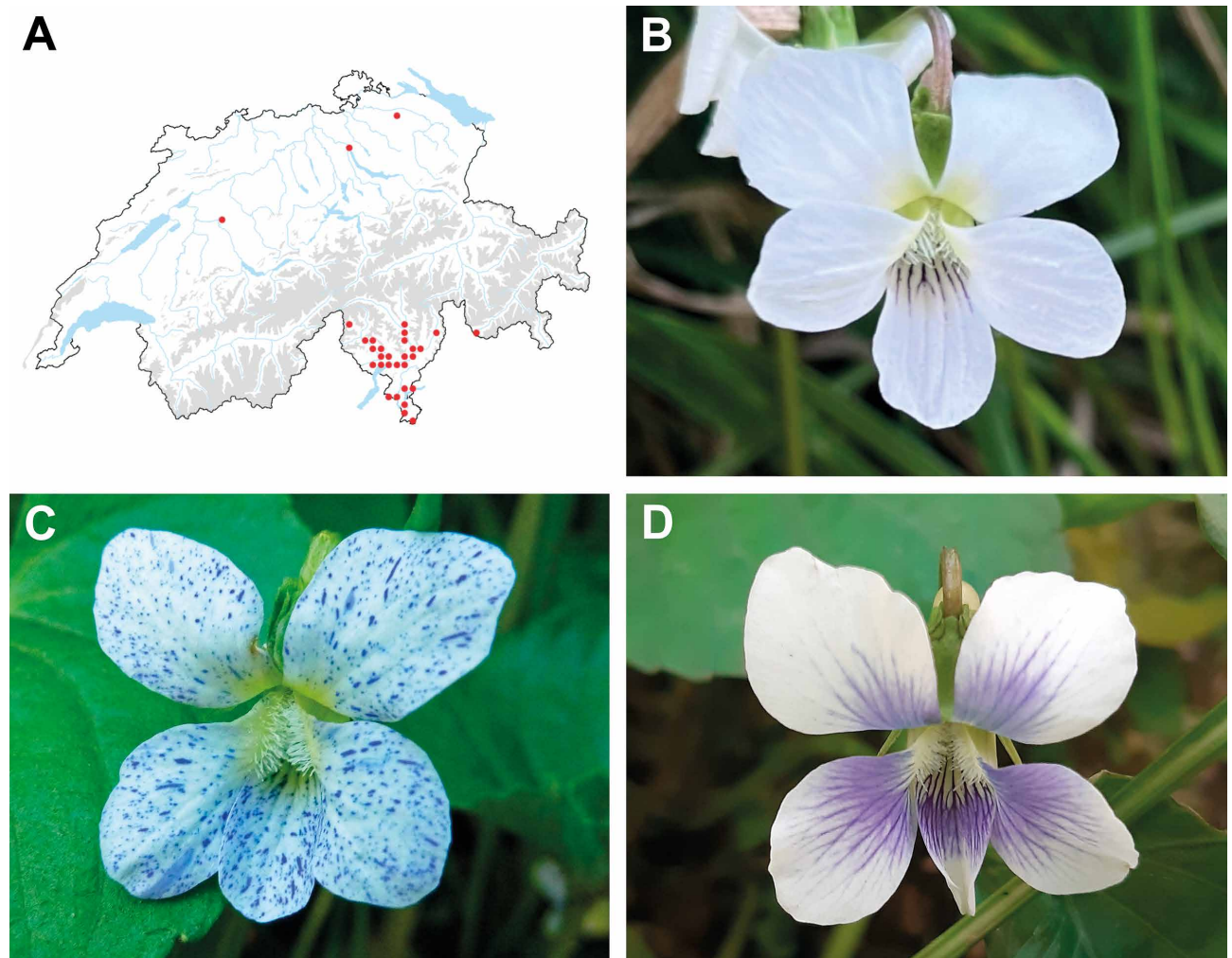


Figure 3: Distribution of *Viola sororia* in Switzerland, and flowers of *Viola sororia* cv. Albiflora, cv. Freckles, cv. Priceana. A: Distribution map of *V. sororia* based on the assumption that records of *V. cucullata* are most likely misidentified *V. sororia*. B: *Viola sororia* cv. Albiflora. C: *Viola sororia* cv. Freckles (credits: James Steakley, CC-BY-SA). D: *Viola sororia* cv. Priceana.

## ACKNOWLEDGMENTS

We would like to thank Adrian Möhl, Jonas Bränhage and Muriel Bendel for having drawn our attention to the problem and motivating this study, Sofia Mangili and Luca Gaggini for valuable comments on this manuscript, and Luca Gaggini also for editorial assistance.

## REFERENCES

- Ballard Jr H.E., Kartesz J.T. & Nishino M. 2023. A taxonomic treatment of the violets (Violaceae) of the northeastern United States and adjacent Canada. *The Journal of the Torrey Botanical Society*, 150: 3-266.
- Balogh L., Dancza I. & Király G. 2004. Actual list of neophytes in Hungary, and their classification according to their success. In: Mihály B. & Botta-Dukát Z. (eds), *Biological invasions: Invasive plants*. Természettudományi Alapítvány, Kiadó, Budapest, pp. 61-92.
- Carvalho L., Fernandes F.M., Nozes P., Figueira A.P., Albuquerque S. & Nunes M. de F. 2023. Women and violets in France (1800-1920) – a visual journey. *Ethnobotany Research and Applications*, 26: 1-22.
- Cullen J., Knees S.G. & Cubey H.S. 1997. *The European Garden Flora Volume 5. Dicotyledons (Part III)*. Cambridge, Cambridge University Press.
- Cooperrider T.S. 1984. Some species mergers and new combinations in the Ohio flora. *Michigan Botanist*, 23: 165-168.
- Desfayes M. 2008. Les opuntias du Valais, un problème épineux: espèces et nomenclature. *Bulletin de la Murithienne*, 125: 29-39.
- Dickoré W.B. & Kasperek G. 2010. Species of *Cotoneaster* (Rosaceae, Maloideae) indigenous to, naturalising or commonly cultivated in Central Europe. *Willdenowia*, 40: 13-45.
- Fischer M.A. & Karrer G. 2005. Familie Veilchengewächse (Violaceae). In: Fischer M.A., Adler W. & Oswald K. (eds), *Exkursionsflora für Österreich, Liechtenstein und Südtirol*. Linz, Biologiezentrum der Oberösterreichischen Landesmuseen, pp. 428-434.
- Fischer M.A., Oswald K. & Adler W. 2008. *Exkursionsflora für Österreich, Liechtenstein und Südtirol*, 3rd edition. Linz, Biologiezentrum der Oberösterreichischen Landesmuseen, 1391 pp.
- Flora Österreichs. 2024. Online-Flora von Österreich. <https://cvl.univie.ac.at/flora/> (last accessed 23.5.2024).
- Galasso G., Conti F., Peruzzi L., Alessandrini A., Ardenghi N.M.G., Bacchetta G., ... & Bartolucci F. 2024. A second update to the checklist of the vascular flora alien to Italy. *Plant Biosystems*, 158: 297-340.
- Hand R., Thieme M. et al. 2024. Florenliste von Deutschland (Gefäßpflanzen), begründet von Karl Peter Buttler, Version 14. <https://www.florenliste-deutschland.de> (last accessed 23.5.2024).
- Hawkes J.G. 1986. Problems of taxonomy and nomenclature in cultivated plants. *Acta Horticulturae*, 182: 41-52.
- Hess H.E., Landolt E. & R. Hirzel. 1970. *Flora der Schweiz* 2. Basel, Birkhäuser, 737 pp.
- Hroneš M. & Kobrová L. 2013. Notulae ad floram Sloveniae. *Viola sororia* Willd. – New locality of an introduced species, with some comments on its cultivars. *Hladnikia Ljubljana*, 31: 51-59.
- Hulme P.E. & Weser C. 2011. Mixed messages from multiple information sources on invasive species: a case of too much of a good thing? *Diversity and Distributions*, 17: 1152-1160.
- InfoFlora, Centro nazionale di dati e informazioni sulla flora svizzera. 2023. Estrazione dati InfoFlora 1.5.2023 (*V. cucullata* Aiton).
- Juillerat P., Bäumlér B., Bornand C., Gygax A., Jutzi M., Möhl A., ... & Eggenberg S. 2017. Checklist 2017 der Gefäßpflanzenflora der Schweiz / de la flore vasculaire de la Suisse / della flora vascolare della Svizzera. Bern, InfoFlora.
- Lauber K., Gerhart W. & Andreas G. 2018. *Flora Helvetica – Flore illustrée de Suisse*. Bern, Haupt Verlag, 1686 pp.
- Little R.J. & McKinney L.E. 2015. *Viola*. In: *Flora of North America Editorial Committee, eds. Flora of North America North of Mexico* 6. New York and Oxford, pp. 111-164.
- Mangili S., Schoenenberger N., Selldorf P., Sasu I., Haritz C., Borsari A., ... & Frey D. 2020. Note floristiche ticinesi 2020: ritrovamento di tre neofite nuove per la Svizzera e di due nuove per il Cantone Ticino. *Bollettino della Società Ticinese di Scienze Naturali*, 108: 83-91.
- Marazzi B., Rosselli A., Galasso G. & Eggenberg S. 2021. *Juglans ailantifolia* – A new alien walnut tree species naturalized in Switzerland and Italy. *Bollettino della Società Ticinese di Scienze Naturali*, 109: 57-68.
- Marazzi B., Mangili S., Gygax A. & Jousson A. 2022. Biology and spread of the new alien species *Coreopsis grandiflora* (Asteraceae) in southern Switzerland. *Bollettino della Società Ticinese di Scienze Naturali*, 110: 57-70.
- Marcussen T., Ballard Jr H.E., Danihelka J., Flores A., Nicola M.V. & Watson J. 2022. A phylogenetic revised classification for the genus *Viola* (Violaceae). *Plants*, 11: 2224.
- Maslo S., Sarajlić N. & Kotrošan D. 2018. *Viola sororia* Willd. (Violaceae): new alien species in the flora of Bosnia and Herzegovina. *Glasnik Hrvatskog botaničkog društva*, 6: 20-24.
- McKinney L.E. & Russell N. 2002. Violaceae of the Southeastern United States. *Castanea*, 67: 369-379.
- Mereda P., Mártonfi P., Hodálová I., Šípošová H. & Danihelka J. 2008. Violaceae Batsch. In: Goliašová K. & Šípošová H. (eds), *Flora of Slovakia VI/1*. Veda Bratislava, pp. 80-190.
- Pliszko A. 2015. New floristic records from the Polish part of the Lithuanian Lakeland. *Steciana*, 19: 25-32.
- Pyšek P., Richardson D.M., Rejmánek M., Webster G.L., Williamson M. & Kirschner J. 2004. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. *Taxon*, 53: 131-143.
- Raab-Straube E. von & Henning T. 2018. Violaceae. In: *Euro+Med Plantbase – the information resource for Euro-Mediterranean plant diversity*.
- Russell N.H. 1957. The Violets of Minnesota. *Journal of the Minnesota Academy of Science*, 25: 126-191.
- Schoenenberger N., Rötliberger J. & Carraro G. 2014. La flora esotica nel Cantone Ticino. *Bollettino della Società Ticinese di Scienze Naturali*, 102: 13-30.
- Shynder O.I., Orlov O.O., Miskova O.I., Chorna H.A. & Shevera M.V. 2023. Current distribution of *Viola sororia* (Violaceae) in Ukraine. *Chornomorski Botanical Journal*, 19: 118-132.
- Spinedi F. & Isotta F. 2004. Il clima del Ticino. Dati, statistiche e società, 6: 4-39.
- Tela Botanica. 2024. *Viola cucullata* Aiton. <https://www.tela-botanica.org/bdtfx-nn-77599-synthese> (last accessed 23.5.2024).



- Tokuoka T. 2008. Molecular phylogenetic analysis of Violaceae (Malpighiales) based on plastid and nuclear DNA sequences. *Journal of Plant Research*, 121: 253-260.
- Tonello M., Fehr V., Conedera M., Hunziker M. & Pezzatti G.B. 2022. Iconic but invasive: The public perception of the Chinese windmill palm (*Trachycarpus fortunei*) in Switzerland. *Environmental Management*, 70: 618-632.
- Xiang J.Q.-Y., Thomas D.T., Zhang W., Manchester S.R. & Murrell Z.E. 2006. Species level phylogeny of the genus *Cornus* (Cornaceae) based on molecular and morphological evidence-implications for taxonomy and Tertiary intercontinental migration. *Taxon*, 55: 9-30.
- Wahlert G.A., Marcussen T., de Paula-Souza J., Feng M. & Ballard Jr H.E. 2014. A phylogeny of the Violaceae (Malpighiales) inferred from plastid DNA sequences: Implications for generic diversity and intrafamilial classification. *Systematic Botany*, 39: 239-252.
- Weakley A.S. & Southeastern Flora Team. 2023. *Flora of the southeastern United States*. Edition of April 14, 2023. University of North Carolina Herbarium (NCU), North Carolina Botanical Garden, University of North Carolina, Chapel Hill, 2105 pp.