

Solanum villosum (Solanaceae) in New Zealand

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Abstract

The distribution of *Solanum villosum* Mill., the red-berried nightshade, as a naturalised species in New Zealand is described. Observations on several distinct small populations of *S. villosum* over the past 20 years from the Gisborne and Christchurch/Lincoln regions of New Zealand are recorded. In addition to the distinguishing red berries, plants from both locations were shown via flow cytometry to be tetraploid. Assessment of herbarium specimens confirm that *S. villosum* has been observed in New Zealand for at least 70 years. Collectively, these records establish that although uncommon, *S. villosum* is fully naturalised and widely distributed in New Zealand. The occurrence of this species has probably been underreported due to confusion with other nightshades, especially in the absence of the characteristic yellow or red berries.

Keywords: Solanaceae – *Solanum villosum* – red-berried nightshade – naturalised species – New Zealand flora – flow cytometry

Introduction

Within the *Solanum* L. genus, the Morelloid clade is one of the ten major clades that encompasses the black nightshades (Särkinen et al. 2018). In the flora of New Zealand this clade is recognised as having two indigenous species (*Solanum americanum* Mill. and *Solanum opacum* A.Braun & C.D.Bouché) and five naturalised species (*Solanum chenopodioides* Lam., *Solanum furcatum* Dunal, *Solanum nigrum* L., *Solanum nitidibaccatum* Bitter, and *Solanum villosum* Mill.) (Schönberger et al. 2021).

The identification of nightshade species has been difficult due to the extreme vegetative plasticity within nightshades, coupled with a wide range of taxonomic interpretations and descriptors. Taxonomic recognition within the Morelloid clade has ranged from all taxa treated as a single highly variable species (usually *S. nigrum*) to the recognition of minor intraspecific variants involving subspecies, varieties and formae that have been transferred and recombined resulting in a plethora of names (Särkinen et al. 2018). The recent thorough taxonomic revision of the Morelloid clade of the *Solanum* genus (Särkinen et al. 2018) has provided clarity with excellent species descriptors and a simple key to species, coupled with the elimination of intraspecific ranks and a clear documentation of synonyms.

The recognition of *S. villosum* (red-berried nightshade) as a naturalised species in the New Zealand flora has had a convoluted history with some taxonomic confusion among various nightshade entities. Healy (1969) provided the first published record of *Solanum villosum* being naturalised in New Zealand, although this was recorded as *Solanum nigrum* var. *puniceum* Gmel. at the time. In the second edition of this book, Healy (1984) referred to *S. villosum* and recognised that the earlier observations were recorded as *Solanum nigrum* var.

puniceum or *Solanum nigrum* var. *minitatum*. Further clarity was provided by Webb et al. (1988, 1989) who noted that *S. villosum* was known from the Gisborne area collected twice in 20 years, and seen once in Christchurch at the Middleton railway yards.

This paper reports further observations over the past 20 years on several distinct small populations of *S. villosum* growing as weeds of either arable crops, on disturbed waste areas, or domestic gardens from the Gisborne and Christchurch regions of New Zealand. An assessment is also provided of herbarium specimens collected from New Zealand sites that can now be ascribed to *S. villosum*. Collectively, these records establish that, although uncommon, *S. villosum* is fully naturalised and widely distributed in New Zealand.

Population locations

Central Christchurch, Canterbury

A small population of ten to twelve nightshade plants was observed during June 1999 growing near Deans Avenue on recently disturbed soil at the disused waste area formerly occupied by the Canterbury Sale Yards. Seed was collected from shrivelled berries on these plants, stored and subsequently germinated at the Canterbury Agriculture and Science Centre, Lincoln, during the spring-early summer of 2007. The resulting nightshade plants were confirmed as having red berries on greenhouse grown plants (voucher specimen CHR 656851). Plants were observed at this and/or neighbouring sites during December 2014, March 2018, and January 2022 (but not found in any other year since first observed).

West Christchurch, Canterbury

In April 2007, several nightshade plants with orange-red berries were found growing in an area about 25-40 m from the branch in railway tracks on a formerly disused site near the corner of Main South Road and Carmen Road. Seed collected from these plants was germinated at the Canterbury Agriculture and Science Centre, Lincoln, during the spring-early summer of 2007. The resulting plants were confirmed as having red berries on greenhouse grown plants (voucher specimen CHR 656852). Plants have not been observed at this site since the original collection, presumably a consequence of commercial building developments in the area.

Lincoln, Canterbury

A population of at least 25 well-established nightshade plants with red berries were observed as weeds on recently cultivated soil in a domestic garden during the late summer-early autumn since 2013 (Fig. 1 and Fig. 2, p. 55). It is possible that this population arose from discarded plants and seed following the growth of the plants at the Canterbury Agriculture and Science Centre, Lincoln. Plants have been observed in this domestic garden and neighbouring properties every year (except 2020) since 2013 (voucher specimens CHR 656943, CHR 656944, and CHR 656945).

Gisborne, Poverty Bay

Solanum villosum was found by John Fletcher (Crop & Food Research) at three sites near Gisborne during disease surveys in vegetable crops in February-March 1994: adjacent to Matawhero Sale Yards (voucher specimen CHR 508237), Saddlers Road, Manutuke (voucher specimen CHR 508238), and near Gisborne Airport (voucher specimen CHR 506549). Further searches of these sites in March 2017 and February 2018 failed to find any *S. villosum* plants. However, in February 2018, several plants of *S. villosum* were observed at two sites within the Makaraka Cemetery, Houhoupiko, Gisborne. Seeds collected from these plants were germinated at the Canterbury Agriculture and Science

Centre, Lincoln, in late 2018, and the resulting plants were confirmed as having red berries on greenhouse grown plants (voucher specimen CHR 656942).



Figure 1. *Solanum villosum* growing in a domestic garden in Lincoln, Canterbury, New Zealand (6 March 2019).



Figure 2. Strongly reflexed calyx lobes on mature fruit of a plant of *Solanum villosum* growing in Lincoln, Canterbury, New Zealand (6 March 2019).

Determination of ploidy level

Solanum villosum is known to be a tetraploid species ($2n = 4x = 48$; Särkinen et al. 2018). In contrast, the other *Solanum* species of the Morelloid clade in the New Zealand flora are either diploid ($2n = 2x = 24$; *S. americanum*, *S. chenopodioides*, and *S. nitidibaccatum*) or hexaploid ($2n = 6x = 72$; *S. furcatum*, *S. opacum*, and *S. nigrum*) (Särkinen et al. 2018). Flow cytometry can be used to estimate ploidy levels of cells by passing many isolated nuclei, labelled with fluorescent dyes, in single file past a laser beam to estimate the amount of DNA in each nucleus. Whether calibrated relative to a known diploid (*S. chenopodioides*) or relative to a known hexaploid (*S. furcatum*), the red-berried nightshade plants from Gisborne and Lincoln were confirmed as having tetraploid status (Table 1, p. 59).

Assessment of herbarium specimens

An assessment was also made of herbarium voucher specimens collected from New Zealand (Table 2, p. 60). In addition to the populations reported in this study (voucher specimens CHR 656851, CHR 656852, CHR 656942, CHR 656943, CHR 656944, CHR 656945), other voucher specimens attributed to *S. villosum* include four from the Gisborne/Poverty Bay area (CHR 418787, CHR 506549, CHR 508237, CHR 508238) and one from Christchurch (CHR 152347). Furthermore, based on *S. nigrum* var. *humile* and *S. nigrum* f. *humile* now being regarded as synonyms of *S. villosum* (Särkinen et al. 2018), a further six voucher specimens were examined and reassigned to *S. villosum*, five growing as weeds from various sites of western and southern Christchurch (CHR 184015, CHR 234549, CHR 234730, CHR 400711, CHR 400715) and one from arable crops at Lincoln (CHR 468705).

Examination of a further five voucher specimens, originally identified as *Solanum* sp. has also allowed reassignment to *S. villosum*, including one from Christchurch (CHR 89285) and four from Upper Hutt (CHR 77084, CHR 77085, CHR 77086, CHR 77087). One voucher specimen (AK 69342) labelled as *S. villosum* from the Mt Albert Research Centre was grown from imported seed; whereas another (AK 253313) labelled as *S. nigrum* f. *humile* collected from Palmerston North is most probably *S. villosum*. Recent observations of *S. villosum* in New Zealand have also been recorded in iNaturalist (<https://inaturalist.nz>). These include several records from the Mohaka River, Te Haroto, Hawkes Bay (30 March 2017 to 7 February 2020) and one from the Canterbury Agricultural Park, Wigram, Christchurch (24 March 2018).

Solanum humile is also regarded as a synonym of *S. villosum* (Särkinen et al. 2018). There is a voucher specimen (CHR 111652, collected by M.E. Gillham, August 1957), originally labelled "*S. humile*?" collected from the entrance to shearwater burrows on the Mokohinau Islands in the Hauraki Gulf. Webb et al. (1989) stated that the first record of *S. humile* was from Esler (1978) but noted that this record cannot be substantiated. However, Esler (1978) attributed *S. humile* to Gillham (1960) and questioned this identification when he failed to find it on the Mokohinau Islands. Our examination of voucher specimen CHR 111652 would suggest that it is not *S. villosum* based on leaf margins and the failure to retain pedicels with the dropping of mature fruit.

Discussion

Assessment of herbarium specimens confirms that *S. villosum* has been present in New Zealand for at least 70 years (Table 2). Collectively, these records establish that although uncommon, *S. villosum* is fully naturalised and widely distributed in New Zealand. Records of *S. villosum* in New Zealand have been mostly from the Gisborne/Hawkes Bay area and the

Christchurch/Lincoln area, but *S. villosum* has also been reported from Upper Hutt and Palmerston North.

Nightshades are difficult to identify due to their extreme vegetative plasticity and their lack of striking distinguishing characters (Särkinen et al. 2018). Consequently, the presence of combinations of characters are most useful for identification. *Solanum villosum* can be easily distinguished from other nightshades by the yellow to bright red colour of mature berries that are slightly elongate to ellipsoid (Fig. 2, p. 55). Among the nightshades present in New Zealand, it is the only tetraploid species (Table 1; Särkinen et al. 2018). However, in the absence of mature berries or the ability to assess ploidy level, it is difficult to distinguish *S. villosum* from other nightshades species, especially *S. nigrum*. Some additional key characteristics of *S. villosum* include filaments 1.0-1.3 mm long, anthers 1.8-2.4 mm long, longer filaments relative to anther length, strongly reflexed calyx lobes on mature fruit (Fig. 2), stone cells always absent from the berries, and pedicels not falling with mature fruit.

Solanum villosum can be readily distinguished from *S. chenopodioides* and *S. nitidibaccatum* on the pubescence of young stems and leaves. *Solanum chenopodioides* has narrow lanceolate leaves with soft grey indumentum and *S. nitidibaccatum* has dense viscid pubescence, whereas other nightshades are pubescent (often sparsely) with simple trichomes. *Solanum nitidibaccatum* also differs from other nightshades with accrescent calyx lobes (becoming larger with maturity) and dark green to green-brown mature fruit with marbled white lines.

The flowers of *S. villosum* are larger than those of *S. americanum*, *S. opacum* and *S. nitidibaccatum*, with corolla diameters of 8-20 mm and anthers 1.8-2.4 mm long. In contrast, *S. furcatum* has larger flowers than *S. villosum*, with corolla lobes being 5.5-7.0 mm long and anthers 2.3-3.6 mm long. *Solanum opacum* is distinguished from other nightshades by unequal calyx lobes with two lobes being larger than the other three lobes. Calyx lobes are appressed in mature fruit of *S. opacum*, *S. furcatum*, *S. chenopodioides* and *S. nitidibaccatum*, whereas calyx lobes are strongly reflexed on the fruit in both *S. villosum* and *S. americanum*, and spreading to reflexed in *S. nigrum*.

Pedicel persistence with fruit ripening is an important species characteristic of nightshades (Särkinen et al. 2018). Ripe berries either fall with the pedicels attached (*S. opacum*, *S. furcatum*, *S. chenopodioides*, *S. nitidibaccatum*) or the berry falls with the pedicel remaining attached to the plant (*S. villosum*, *S. americanum*, *S. nigrum*). In the absence of mature fruit, *S. villosum* is very similar to *S. nigrum*. The calyx lobes of *S. villosum* are generally longer (relative to width) than those of *S. nigrum*. They are also strongly reflexed on mature fruit with a rounded sinus between the calyx lobes rather than a more acute sinus in *S. nigrum* (Särkinen et al. 2018). In flowers of *S. villosum*, the calyx tube has a pale translucent zone below the sinus between the calyx lobes.

The uncommon occurrence of *S. villosum* in New Zealand may, in part, be a consequence of underreporting due to the difficulty in distinguishing this species from other nightshades. We have noticed that plants growing in the Lincoln area only mature to develop the characteristic yellow-orange-red ripe fruit when the autumn period is relatively warm. In the absence of this distinguishing feature, the plants are probably assumed to be *S. nigrum*. It is also possible that the uncommon occurrence of *S. villosum* is a consequence of competition for habitats from other nightshade species. Särkinen et al. (2018) comment that *S. villosum* is much more common in southern Europe than *S. nigrum*, while *S. nigrum* is more common in northern and central Europe. It is possible that with global warming, *S. villosum* may become more competitive relative to other nightshades in New Zealand and start to become a more prevalent weed in response to climate change.

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Table 1. Determination of ploidy level by flow cytometry analysis. The ploidy level for *Solanum* species of the Morelloid clade in New Zealand was estimated relative to a known diploid and hexaploid^a. *Solanum villosum* is represented by two populations from both Gisborne (HW, IW) and Lincoln (NS, OS).

<i>Solanum</i> species	Chromosome number (2n) ^b	Population	Estimated ploidy level (mean ± SD; n = 4) relative to:	
			<i>Solanum chenopodioides</i>	<i>Solanum furcatum</i>
<i>Solanum americanum</i>	24	Kekerengu, Marlborough	2.0 ± 0.0	2.1 ± 0.0
<i>Solanum chenopodioides</i>	24	Lincoln, Canterbury	2.0 ± 0.0	2.1 ± 0.0
<i>Solanum nitidibaccatum</i>	24	Lincoln, Canterbury	2.7 ± 0.0	2.8 ± 0.0
<i>Solanum furcatum</i>	72	Hapuku River, Kaikoura	5.7 ± 0.1	6.0 ± 0.1
<i>Solanum nigrum</i>	72	Lincoln, Canterbury	5.6 ± 0.1	6.0 ± 0.1
<i>Solanum villosum</i> (HW)	48	Gisborne, Poverty Bay	3.7 ± 0.0	3.9 ± 0.0
<i>Solanum villosum</i> (IW)	48	Gisborne, Poverty Bay	3.8 ± 0.0	4.0 ± 0.0
<i>Solanum villosum</i> (NS)	48	Lincoln, Canterbury	3.8 ± 0.0	4.0 ± 0.0
<i>Solanum villosum</i> (OS)	48	Lincoln, Canterbury	3.8 ± 0.0	4.0 ± 0.0

^a Ploidy status was determined on a Sismex CyFlow Space Ploidy Analyser, operating Flowmax software. Nuclei were extracted from leaf samples into a buffer (2% citric acid, 0.5% Tween 20) and stained with a DAPI solution (2.5 ug/ml 4',6-diamidino-2-phenylindole in saturated di-sodium hydrogen orthophosphate). Red clover (*Trifolium pratense* L.; 0.97 pg DNA/2C nucleus) was used as an internal standard. Estimates of ploidy level were determined relative to measurements of the diploid *S. chenopodioides* and the hexaploid *S. furcatum*. Flow cytometry analysis was conducted on two technical replicates for each of four biological replicates consisting of separate individual plants.

^b From Särkinen et al. (2018).

Table 2. Herbarium records of *Solanum villosum* in New Zealand.

Voucher specimen	Collection location	Collection date	Collector	Notes
CHR 77084 CHR 77085 CHR 77086 CHR 77087	Wallaceville Research Station, Upper Hutt	23 April 1952	T.W. Rawson	Originally identified as <i>Solanum</i> sp.; yellow berries
CHR 89285	Lake Bryndwr, Christchurch	18 March 1955	R. Mason	Originally identified as <i>Solanum</i> sp.
AK 69342	Mt Albert Research Centre, Auckland	1 January 1959	C. Cambie	Ex Denmark (Jorgenson); n = 24. Grown for Chemistry Dept, Auckland University College; Summer 1959
CHR 152347	Seed collected from Gisborne district by A J McNeur	13 April 1964	A.J. Healy	Plants cultivated at Botany Division DSIR Lincoln. Originally recorded as <i>S.</i> <i>nigrum</i> var. <i>puniceum</i>
CHR 184015	Lake Bryndwr, Christchurch	2 April 1968	A.J. Healy	Originally recorded as <i>S.</i> <i>nigrum</i> var. <i>humile</i> ; yellowish berry
CHR 234549	Single pits Sockburn, Christchurch	22 April 1972	A.J. Healy	Originally recorded as <i>S.</i> <i>nigrum</i> ; yellowish berry
CHR 234730	Bare land between Riccarton Mall and Matipo Service Station	15 April 1974	A.J. Healy	Originally recorded as <i>S.</i> <i>nigrum</i> var. <i>humile</i> ; single plant eglandular
AK 253313	John F Kennedy Drive, Milson, Palmerston North	13 March 1981	unknown	Recorded as <i>S. nigrum</i> f. <i>humile</i>
CHR 400711	Seed collected from Riccarton, Christchurch by A J Healy	5 May 1983	W.R. Sykes	Plants cultivated at Botany Division, DSIR, Lincoln. Originally recorded as <i>S.</i> <i>nigrum</i> f. <i>humile</i> ; yellowish berry
CHR 400715	Seed collected from Riccarton, Christchurch by A J Healy	29 April 1983	W.R. Sykes	Plants cultivated at Botany Division, DSIR, Lincoln. Originally recorded as <i>S.</i> <i>nigrum</i> f. <i>humile</i> ; yellow berry

Voucher specimen	Collection location	Collection date	Collector	Notes
CHR 418787	Seed collected from Poverty Bay	April 1983	W.R. Sykes	Plants cultivated at Botany Division, DSIR, Lincoln. Orange-red berries; 2n = 48
CHR 468705	Duncan's Farm, Lincoln1	6 March 1991	R. Scott	Originally recorded as <i>S. nigrum</i> f. <i>humile</i> ; dull yellowish berry
CHR 506549	Near Gisborne airport	14 February 1994	J. Fletcher, H. Nott	Lacks glandular hairs
CHR 508237	Adjacent to Matawhero Sale Yards, Gisborne	1 March 1994	J. Fletcher	Red berries
CHR 508238	Manutuke, Saddlers Rd, near Gisborne	1 March 1994	J. Fletcher	Red berries
CHR 656851	Seed collected from Old Canterbury Sales Yards, Deans Ave Christchurch	June 1999	T. Conner	Plants grown at the Canterbury Agriculture and Science Centre, Lincoln. Red berries.
Voucher specimen	Collection location	Collection date	Collector	Notes
CHR 656852	Seed collected from corner of Main South Rd and Carmen Rd, Hornby, Christchurch	April 2007	T. Conner	Plants grown at the Canterbury Agriculture and Science Centre, Lincoln. Red berries.
CHR 656942	Seed collected from Makaraka Cemetery, Gisborne	February 2018	T. Conner	Plants grown from collected seed at the Canterbury Agriculture and Science Centre, Lincoln. Red berries.
CHR 656943	The Mews, Lincoln, Canterbury	March 2013	T. Conner	Growing as a weed in domestic garden. Red berries.
CHR 656944	The Mews, Lincoln, Canterbury	April 2017	T. Conner	Growing as a weed in domestic garden. Red berries.
CHR 656945	South Belt, Lincoln, Canterbury	March 2013	T. Conner	Growing as a weed in domestic garden. Red berries.