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The Biology and Ecology of *Torenia* (*Torenia X hybrida*) in Australia

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PREAMBLE

This document addresses the biology and ecology of *Torenia X hybrida*, with particular focus on its cultivation and use in Australia. Information included relates to the taxonomy and origins of cultivated torenia, general descriptions of its morphology, reproductive biology, physiology, biochemistry, biotic interactions, toxicity, allergenicity and weediness. This document also addresses the potential for gene transfer to occur to closely related species. The purpose of this document is to inform risk assessments of genetically modified (GM) torenia that may be released into the Australian environment.

In this document, torenia is used to refer to *T. X hybrida* and its cultivars, and to hybrids of *T. fournieri* and *T. concolor*, which are commonly referred to in trade, botanical and horticultural literature as torenia.

SECTION 1 TAXONOMY

Torenia, wishbone and blue wings are common garden names for various species of torenia (*T. fournieri*, *T. concolor*, *T. X hybrida* and *T. asiatica*). The common name ‘wishbone’ is derived from the chicken wishbone shaped stamens, which are popularly believed to bring luck (The Old House Web 2006; University of Arkansas 2006; Michigan State University 2006). *Torenia* was named after Olof Toren (1718-1753), a Swedish clergyman who travelled to China for the Swedish East India Company in the middle of the 18th Century.

Torenia spp. are dicotyledons, belonging to the class *Magnoliopsida*, order *Scrophulariales* and family *Scrophulariaceae*, which is commonly known as the ‘figwort family’. The *Scrophulariaceae* comprise 306 genera and approximately 5850 species. There are discrepancies in the number of torenia species mainly because the genus has been insufficiently studied in the Indochina region. Based on herbarium specimens, Yamazaki (1985) reported a total of 50 torenia species, 20 of which were from Cambodia, Laos and Vietnam, and 19 from Thailand. Other reports indicate that there are 40 species of torenia (Fischer 2004; Spencer 2006). *T. X hybrida* (cv Summerwave[®]) is an inter-specific hybrid of *T. fournieri* and *T. concolor* (Fischer 2004; USDA 2006; Spencer 2006).

SECTION 2 ORIGIN AND CULTIVATION

2.1 Centres of diversity

The centre of origin and divergence of members of the family *Scrophulariaceae* are often mountain ranges. The origin of *Torenia* spp. is not known (Fischer 2004), although it is reportedly native to South East Asia, Africa and Madagascar (Yamazaki 1985).

Almost all species of torenia occur in tropical and subtropical Asia, Africa and Madagascar. Details on the distribution of a few well known species of torenia are given in Table 1. One species of torenia, *T. thouarsii* cham & schtdl, was reportedly introduced into tropical America (Fischer 2004).

Table 1: Distribution of *Torenia* spp. (Yamazaki 1985; Tanimoto & Harada 1990; Harvard University 2006)

<i>Botanical name</i>	<i>Common name</i>	<i>Occurrence / distribution</i>
<i>T. asiatica</i>	wishbone	India, Burma, Thai and Malay
<i>T. flava</i>	unknown	Assam, Burma, Malay Peninsula, Sumatra, Java, Thailand, Laos, Vietnam, S. China and Taiwan.
<i>T. benthamiana</i>	unknown	Vietnam and S. China
<i>T. concolor</i>	torenia wishbone	Laos, Vietnam and S. China
<i>T. fournieri</i>	blue wings torenia wishbone	Thailand, Cambodia, Laos and Vietnam, Cochin China

2.2 Domestication and Use

As mentioned in Section 2.1, members of the family *Scrophulariaceae* are found mostly in tropical mountains, particularly in open rather than forested areas. *Torenia*s are prevalent in disturbed habitats such as roads and paths, clearings, plantations and around settlements (Fischer 2004). There are reports of *torenia* growing in ‘open swamps’, wet rocks on open slopes or by streams, moist ground in evergreen forests and lowlands, and at altitudes of 300-1200m (Yamazaki 1985).

Torenia cultivars or varieties that produce violet flowers, were the only types commercially available for a long time until Pan American Seed (Illinois, USA) released the crown series in 1988, which included pink, white and reddish/purple flower colour lines. In 1995, Suntory Ltd. (Osaka, Japan) introduced the creeping-type *torenia* ‘Summerwave[®]’ (*T. X hybrida*) series, an interspecific hybrid of *T. fournieri* and *T. concolor*. The release of these cultivars has increased the popularity of *torenia* in Japan, the US, Canada and Australia (Aida & Shibata 1999) (DAFF 2000).

Torenia spp. have an extended history of cultivation and safe use as an ornamental plant and are usually found in nurseries, home gardens and landscaping situations (ie. flower beds). *Torenia* have been grown as a front border plant especially in lightly shaded areas and are popularly grown in hanging baskets or as trailer specimens in patio planters. Apart from its ornamental value, *T. fournieri* is a useful experimental model plant for cytogeneticists to study fertilization, because of the ease of observing fertilisation due to the protruding nature of the embryo sac. *T. fournieri* is also used to study the location and movement of chromosomes and their centromeres in the early stages of embryogenesis in interspecific hybrid plants (Kikuchi et al. 2005).

2.3 Cultivation in Australia

Torenia (cv ‘Sunrenilapiho[®]’ and ‘Sunrenirirepa[®]’, synonym ‘Amethyst Magic[®]’) is listed in the Plant Varieties Journal of the Department of Agriculture, Forestry and Fisheries (DAFF) and was approved for breeding and cultivation in Australia (DAFF 2000). *T. X hybrida* and *T. fournieri* have been introduced into most States of Australia, including the tropics and subtropics. *T. X hybrida* is commercially available from nurseries and is being grown in Victoria, New South Wales (NSW), South Australia, and the Australian Capital Territory (ACT) with limited availability in

Queensland. *Torenia* spp. tolerate hot summers and are a good substitute for pansies, which do poorly in regions with mild winters

2.4 Crop improvement

Suntory Flowers (Japan) developed *T. X hybrida* cultivars ‘Summerwave[®]’, blue and ‘Summerwave[®]’, violet by interspecific (between species of the same genera) hybridisation of *T. fournieri* Lind. and *T. concolor* Lind. Innovative breeding work on torenia by Suntory Flowers, by crossing tropical species exhibiting strictly trailing habit (*T. concolor*) with the upright *T. fournieri* type, gave rise to *T. X hybrida*, a plant with characteristics of both parents, including long and creeping branches, heat tolerance and profuse flowering capability (LookSmart 2005).

Torenia spp. can be propagated asexually mainly by cuttings, although it has no specific means of vegetative reproduction such as stolons or rhizomes. *T. X hybrida* is vegetatively propagated in specialist nurseries by using tissue culture techniques to obtain plants from cuttings. Even though the plants are capable of producing adventitious roots on trailing stems, they cannot survive to produce plants under natural conditions (Tanimoto & Harada 1990; Florigene 2006).

Torenia is generally a diploid (n=9) plant. Tetraploids (n=18) can be induced by colchicine treatment of young seedlings and has relatively large flowers offering potential for developing better horticultural varieties. However these tetraploids exhibit significant reduction in pollen viability, seed setting and unequal distribution of chromosomes at anaphase when compared to their diploid progenitors (Tandon & Bhutani 1965).

Current torenia breeding programs aim to produce varieties with novel flower colours, increased flower production, early flowering and enhanced survival and disease resistance. As *T. X hybrida* is male and female sterile and does not produce viable pollen or set seed, it is not possible to expand the variation in desirable horticultural characteristics without using artificial mutagenesis (Miyazaki et al. 2006) or gene transformation techniques (Nakamura et al. 2006).

Recently *T. X hybrida* was identified as a versatile model system for use in transformation technology to study morphogenetic responses. Given that torenia can be grown easily under laboratory/field conditions and has high genetic transformation efficiency, scientists and horticulturist have now recognised its potential for epocha cultivar breeding (Aida et al. 1998; Tao & Li 2006). *In vitro* tissue culture requirements for *T. X hybrida* have been well established (Tanimoto & Harada 1990) and plant tissue can readily differentiate into adventitious structures and regenerate plants (transformation frequency of 90%) (Aida & Shibata 1999; Aida & Shibata 2001).

Aida and Shibata (1995) were the first to genetically modify torenia. For over a decade, torenia have been successfully genetically modified using *Agrobacterium* (*A. tumefaciens* & *A. rhizogenes*) mediated transformation technology, to produce modified flowers with wavy patterns, novel colours and extended longevity (Aida et al. 1998; Aida et al. 2000a; Aida et al. 2000b; Aida et al. 2001).

SECTION 3 MORPHOLOGY

3.1 Plant morphology

T. X hybrida is a trailing annual or perennial plant and is usually a fast growing creeper, with a cascade-type morphology. Their growth habit is generally prostrate and plants can reach a height of 45 to 60cm with a spread of 60cm. *Torenia* (including *T. X hybrida*) grows well in moist well-drained soil and can reach a height of 15cm in the shade and 30 cm in full sun.

The stems of *torenia* are quadrangular and the leaves simple, cauline, arranged opposite and sub sessile to petiolate. The lamina are lanceolate (lance shaped 3-4 times long as broad and tapering at the apex) ovoid to orbicular, acuminate or obtuse with serrate or dentate margins and pinnately nerved. *Torenia* plants flower vigorously producing deep, blue, violet and amethyst colour flowers during the growing season (Yamazaki 1985).

3.2 Reproductive morphology

In general, *Torenia* spp. (*T. fournieri*, *T. concolor*, *T. asiatica* and *T. X hybrida*) produce flowers that are distinctly pedicellate solitary and axillary, although they may produce flowers in terminal or pseudo axillary racemes or in sub umbels with pedicels quadrangular. The calyx (sepals) of the flower is tubular to broadly ellipsoidal and poricidal. The calyx is labiate or sub-equally 4-lobed, 5-winged or keeled with the upper-lip trinerved and trilobed and the lower-lip binerved and bilobed. The corolla (petals) of the flower is violet or blue, bilabiate (2-lipped), 2.5-3.5cm long with a cylindrical tube. The upper-lip is broadly orbicular (orb shaped), entire or bilobed and lower-lip contains three rounded spreading lobes (Yamazaki 1985; Fischer 2004).

A typical *torenia* flower consists of four fertile, exserted didynamous (in two pairs of unequal length) stamens; anterior filaments each with or without a spur arising slightly above the base. Anthers cohere in pairs and shed pollen with force using a lever action. The ovary is oblong, ovoid, apiculate (small abrupt point) and shortly pilose (soft long weak hairs) at the upper part. The style is filiform (threadlike) and stigma is bilamellate (two thin plate like layers). The fruiting body, the capsule, is narrowly oblong or ellipsoidal, protected and enclosed by a persistent calyx. It is poricidal, septicidally bivalved and separated from the placentiferous column. Seeds are small (0.5mm long and 0.3mm wide), numerous, shortly cylindrical or ellipsoidal and scrobiculate (rarely longitudinally ridged) (Fischer 2004).

SECTION 4 REPRODUCTION

4.1 Reproductive development

A number of horticultural conditions and environmental factors influence flower development in *torenia*. Light, temperature, pest control, timing of fertiliser application, soil type and pH, and horticultural practices are some of the important factors that determine profuse flowering. *Torenia* plants grow well in moist to wet soils and require warm days, with temperatures ranging between 21-25 °C to stimulate profuse flower production.

To maintain profuse flower production during the summer and to revive plants that have stopped flowering, horticulturists recommend pruning and the application of fertiliser every two or three weeks. Flowering is seasonal in *Torenia* and is dependent on climatic conditions (North Haven Gardens 2006; The Old House Web 2006; University of Arkansas 2006).

Torenia spp. can flower and yield seeds (excluding *T. X hybrida*). However *T. X hybrida* is a sterile hybrid, which has sterile male and female reproductive organs and therefore cannot produce seeds. *T. X hybrida* can be pollinated artificially and set seed under *in vitro* tissue culture conditions, which is one of its merits as an experimental plant (Suzuki et al. 2000; Florigene 2006).

4.2 Pollination and pollen dispersal

The genera of *Scrophulariaceae* are mainly insect pollinated. *Torenia* spp. (excluding *T. X hybrida*) are apparently insect pollinated and produce numerous seeds. One of the parents of *T. X hybrida* (*T. fournieri*) is mainly bee pollinated (Yamazaki 1985; Fischer 2004; Florigene 2006).

Torenia produce numerous tiny pollen grains and are approximately $22\pm 4 \times 33\pm 7 \mu\text{m}$. The anthers of *T. fournieri* shed pollen forcibly by lever action. A flange like outgrowth of the lateral pollen sac wall of the anther forms a lever and assists in shedding the pollen. When pressed this lever causes an infolding of the thinner, subadjacent pollen sac wall thereby pushing pollen out from the stomium of the anther. It was estimated that a force of 1.0-1.5g pressing against the four levers of an anther, could result in the forcible shedding of approximately 2,000-3,000 pollen grains in two parallel rows. When mechanical pressure is exerted on the anthers they exhibit a propel action, an adaptation that facilitates efficient pollination. (Armstrong 1992; Watanabe et al. 2006)

Using *in vitro* techniques Suntory (Japan) conducted a comparative study on ovules and pollen viability between *Torenia* spp. (*T. fournieri* and *T. concolor*) and *T. X hybrida*. Microscopic examination revealed that pollen grains were misshapen and non-viable in *T. X hybrida* (of the 1091 pollen grains examined, 97% derived from *Torenia* spp. germinated compared to 0% germination in *T. X hybrida*). Other experiments indicated that 99.5% of 637 ovules were non-aborted in *Torenia* spp. (*T. fournieri* and *concolor*) compared to all 864 aborted ovules of *T. X hybrida* (Florigene 2006).

4.3 Fruit development and seed dispersal

The most common fruit type in the family *Scrophulariaceae* is the capsule. In *Torenia* spp. (*T. fournieri*, *T. concolor* and *T. asiatica*) the capsule dehisces transversally by splitting at the septum and separating from the placenta that is positioned between two movable valves. A special case of poricidy occurs in *T. fournieri* where the fruiting body opens adjacent to the septum on each side producing longitudinal pores. This is followed by the septa separating from the placenta emptying the capsule while the septum splits. At the time of poricidal dehiscence of the capsule the calyx splits longitudinally. In *Torenia* spp. (excluding *T. X hybrida*), seeds are numerous, minute and wind dispersed (Yamazaki 1985; Fischer 2004).

SECTION 5 PHYSIOLOGY AND BIOCHEMISTRY

5.1 Seed dormancy and germination

Torenia seeds are tiny, slow growing and for germination should be placed uncovered on the surface of compost. Seed usually takes 14-30 days to germinate in the shade at temperatures of 21-24 °C. Peat is preferred rather than fertiliser and well-drained soil is recommended. Air should be admitted gradually once the seeds have germinated, otherwise the seedlings may “damp-off”. Information on seed dormancy is not available (North Carolina State University 2000; North Haven Gardens 2006; The Old House Web 2006; University of Arkansas 2006).

5.2 Growth and development

Torenia plants prefer shade to semi shade, are heat tolerant when well watered, but perform poorly in cold climates. When growing *torenia* plants it is recommended to use a medium with adequate drainage, water and nutrient holding capacity. *Torenia* does well in moist to wet soils and requires warm days for optimum growth. It prefers a soil pH between 5.5 and 6.5 (North Haven Gardens 2006; The Old House Web 2006).

Torenia plants are not tolerant to salt, drought or extreme cold (Fischer 2004; North Haven Gardens 2006; The Old House Web 2006; University of Arkansas 2006). Since *torenia* is susceptible to powdery mildew (Anderson 2002; LookSmart 2005; North Haven Gardens 2006; The Old House Web 2006; University of Arkansas 2006) a broad spectrum fungicide is recommended during the early stages of growth. Some species of *torenia* (*T. fournieri*, *T. X hybrida* and *T. asiatica*) are relatively tolerant to low temperatures. *T. X hybrida* was bred specially as a pot plant, rather than an in-ground plant. In this habitat, *T. X hybrida* is typically an annual, which dies back during the winter in temperate regions or as a result of disease, insect infestation or general deterioration.

5.3 Biochemistry of *torenia* flower colour

Aesthetically, flower colour is one of the most important characteristics for the floriculture industry. While the types, ratios and concentrations of floral pigments play a key role in determining flower colour, other important factors include vacuolar pH (the site of pigment accumulation), the structure of the pigments, the presence of co-pigments, light reflection and the size, shape and surface striations of petal epidermal cells (Aida et al. 2000b; Yamaguchi et al. 2001; Nakayama et al. 2003).

Besides carotenoids and betalains, the main pigments contributing to flower colour in *Torenia* spp. (and in fact many other plant species) are the anthocyanins, which are a subclass of flavonoids. Anthocyanins are water-soluble pigments, responsible for the red, blue and purple colour of flowers (and other plant tissues such as fruit and leaves). Anthocyanins exist as glycosides or acylglycosides of their respective aglycone anthocyanidins. There are six major anthocyanidins: pelargonidin, cyanidin, peonidin, delphinidin, petunidin and malvidin (Suzuki et al. 2000).

The anthocyanin biosynthetic pathway in petunia, maize and snapdragon has been extensively studied (Mol-Joseph et al. 1989; Forkmann 1991; Holton & Cornish 1995). The first specific enzymes in the flavonoid and anthocyanin biosynthesis are

chalcone synthase (CHS) and dihydroflavonol 4-reductase (DFR), respectively. The genes encoding these enzymes have been isolated, characterised and cloned from maize, snapdragon and petunia. The biosynthetic pathways in these plants, including *torenia* (Suzuki et al. 2000), share the majority of common reactions; however there are some important differences between the types of anthocyanins produced in different species. A major difference is that petunia does not normally produce pelargonidin pigments whereas snapdragon and maize are incapable of producing delphinidin pigments. *Torenia* produces both delphinidin (responsible for purple or blue flower colour) and pelargonidin (responsible for orange or brick-red flower colour) pigments. *T. X hybrida* cv 'Summerwave[®]' produces four anthocyanidins, namely malvidin (76.4%), peonidin (18.8%), petunidin (2.9%) and cyanidin (1.9%) (Miyazaki et al. 2006).

The precursors of the synthesis of all flavonoids, including anthocyanins, are malonyl-CoA and *p*-coumaroyl-CoA which produce tetrahydroxychalcone. Chalcone isomerase (CHI) then catalyzes the stereoisomerisation of the yellow coloured tetrahydroxychalcone to the colourless naringenin. Naringenin is subsequently converted to dihydrokaempferol (DHK) by flavanone 3 β -hydroxylase (F3H). DHK then gets hydroxylated by the enzyme flavonoid 3-hydroxylase (F3'H) to produce dihydroquercetin (DHQ) or by flavonoid 3'5'-hydroxylase (F3'5'H) to produce dihydromyricetin (DHM). F3'5'H can also convert DHQ to anthocyanins. All three enzymes are crucial for converting the colourless dihydroflavonols (DHQ, DHK, and DHM) to anthocyanins.

The first three enzymatic conversions in anthocyanin biosynthesis is the reduction of dihydroflavonols to flavan-3, 4-cis-diols (leucoanthocyanidins) by dihydroflavonol 4-reductase (DFR) and anthocyanidin synthase (ANS). Further oxidation, dehydration, and glycosylation of the different leucoanthocyanidins produce the corresponding brick-red pelargonidin, red cyanidin and blue delphinidin pigments. Cytochrome P450 is an important component and is almost always essential in the production of blue to purple pigmentation. Anthocyanidin 3-glucosides may be modified further in many species by glycosylation, methylation and acylation as seen in Figure 1. It is important to note that there are species and variety differences in the extent of modification and the types of glycosides and acyl groups (Holton & Cornish 1995).

T. X hybrida cv Summerwave[®] produces the anthocyanidins, cyanidin and delphinidin (Suzuki et al. 2000; Ueyama et al. 2006). Cyanidin is the precursor to the anthocyanin peonidin 3-glucoside 5-(*p*-coumaroyl)-glucoside, delphinidin is the precursor to the anthocyanidin, malvidin-3 glucoside-5-(*p*-coumaroyl)-glucoside and leucopelargonidin is the precursor to the anthocyanidin, pelargonidin. As a result of breeding and gene manipulation *Torenia* spp. produce a range of flower colours, including white, pink, yellow, purple, blue and violet due to differences in the concentrations, ratios and types of anthocyanins and flavonoids produced.

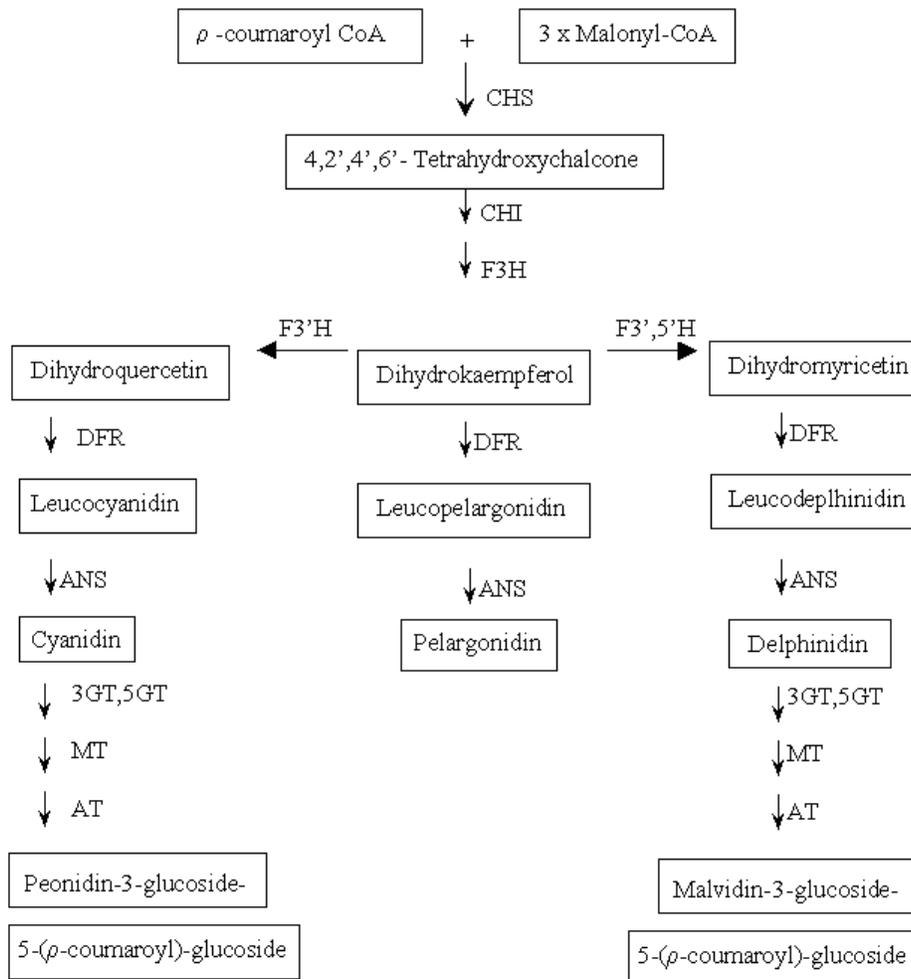


Figure 1. Schematic representation of the anthocyanin biosynthesis pathway in *T. X hybrida* cv 'Summerwave[®] Blue' (Suzuki et al. 2000). [CHS: chalcone synthase; CHI: chalcone isomerase; F3H: flavanone 3 β -hydroxylase; F3'H: flavonoid 3'-hydroxylase; F3'5'H: flavonoid 3'5'-hydroxylase; DFR: dihydroflavonol 4-reductase; ANS: anthocyanidin synthase; 3GT: UDP-glucose/flavonoid-3-O-glucosyltransferase; 5GT: UDP-glucose/flavonoid-5-O-glucosyltransferase; MT: anthocyanin O-methyltransferase; AT: anthocyanin acyltransferase]

SECTION 6 BIOTIC INTERACTIONS

6.1 Weeds

In landscaping situations where torenias are grown in-ground as bedding or in patio trailers, they can be rapidly swamped by weeds. On this basis, home gardeners are generally advised to monitor and physically remove common weeds. Weeds can also be reduced by the use of weed mats, mulches or broad spectrum herbicides. Commercial growers cultivate torenia in greenhouses using sterile soil, which improves weed and disease management (North Haven Gardens 2006; The Old House Web 2006).

6.2 Insects

Torenia spp. are reported to be susceptible to common pests of herbaceous ornamental plants, such as thrips, aphids and mites. Viruses can be transmitted by insects, primarily aphids, leafhoppers and thrips.

6.3 Diseases

Torenia spp. are reportedly susceptible to certain fungal pathogens like *Botrytis* and powdery mildew (*Oidium* spp.) (Holocomb 1999). Symptoms include leaf distortion and yellowing. Conditions like high relative humidity, crowded conditions and poor air circulation favour spread of powdery mildew. Powdery mildew can be prevented by spraying with a broad spectrum fungicide and watering the plant early in the day. Other powdery mildew pathogens reported on *T. fournieri* are *Sphaerotheca fuliginea* (Schlechtend: Fr.) Pollacci in Finland and Japan and an *Erysiphe* spp. in Japan (Holocomb 1999). In the US, *T. fournieri* is reportedly susceptible to root knot nematodes and has shown very light infestation with few scattered galls. (College of Agriculture and Life Sciences 2000; LookSmart 2005).

In recent years the Tobacco mosaic virus and Impatiens Necrotic Spot Tospovirus have been reported on *torenia* spp., (*T. fournieri*) showing necrotic spots on stems and apices (Roggero et al. 1999; University of Connecticut 2006).

T. fournieri is reportedly susceptible to many viruses including abelia latent tymovirus, apple mosaic ilarvirus, arabis mosaic nepovirus, carnation mottle carmovirus, carnation ringspot dianthovirus, cherry leaf roll nepovirus, cloverwound tumor phytoreovirus, clover yellow mosaic potyvirus, clover yellow vein potyvirus, cymbidium ringspot tobusvirus, dogwood mosaic nepovirus, foxtail mosaic potyvirus, groundnut eyespot potyvirus, maize eyespot virus, peach enation nepovirus, pelargonium line pattern carmovirus, peanut clump furovirus, peanut stunt cucumovirus, strawberry latent ringspot nepovirus, sweet potato mild mottle ipomovirus, tobacco etch potyvirus, tobacco ringspot nepovirus, tobacco streak ilarvirus, tomato black ring nepovirus and watermelon mosaic 2 potyvirus (VIDE 1997).

SECTION 7 TOXICITY AND ALLERGENICITY

Throughout the world *Torenia* spp. are widely grown ornamental plants and are not known to be poisonous to people or other organisms. A comprehensive search of the scientific literature¹ and an examination of a number of toxic plant databases² (Cornell University Poisonous Plant Information Database; Canadian Poisonous Plants Information System; FDA Poisonous Plant Database; Toxic Plant Database, Veterinary Library, University of Illinois, USA; Toxic Plant Database, University of Purdue, USA) revealed no evidence that *torenia* has any toxic or allergenic potential to people or is toxic to other organisms.

¹ A variety of databases and search engines were utilised using “*torenia*” as the search term (PubMed; Toxnet; Scirus and Google Advanced). The search was then refined using the term “toxicity”.

² <http://www.ansci.cornell.edu/plants/> http://www.cbif.gc.ca/pls/pp/poison?p_x=px
<http://www.cfsan.fda.gov/~djw/plantox.html> <http://www.library.uiuc.edu/vex/toxic/intro.htm>
<http://www.vet.purdue.edu/depts/addl/toxic/cover1.htm>

SECTION 8 WEEDINESS

A number of *Torenia* spp. are classified as “naturalised” or “weeds” in various parts of the world including *T. asiatica* L. (US), *T. bicolor* Dalz. (global), *T. concolor* Lindl. (global), *T. flava* Bth. (Java), *T. fournieri* Linden ex Fourn. [Guyana, Surinam French Guiana and the US, (Florida)], *T. polygonoides* Benth. (Thailand), *T. spicata* Engl. (global), *T. thouarsii* (Cham. & Schltld.) Kuntze. (global; Guyana, Surinam French Guiana) and *T. violacea* (Azaola ex Blanco) Pennell (Java, Global, Indonesia, The Tropics and China) (Randall 2002). There are no reports or information to suggest that these, or any other *Torenia* spp., are weeds in Australia.

There is little information on the possible weediness of *Torenia* spp. (*T. X hybrida* and *T. fournieri*) in Australia given that they have only been commercially available for a relatively short period of time (about 5 years). A survey of *Torenia* spp. on public access database online (Weeds Australia 2006) generated no records of *Torenia* spp. being a weed or a noxious weed in Australia. Further, the parent species of *T. X hybrida*, *T. concolor* or *T. fournieri*, are not listed as noxious weeds in the US (<http://plants.usda.gov>) or Australia (Groves et al. 2003).

Given that *Torenia* spp. have not been in domestic use for long in Australia or other parts of the world, it is too early to predict their possible weedy characteristics. However it is important to note that *T. X hybrida* does not possess any characteristics typical of weeds since it does not produce any viable seed, cannot spread by vegetative means under natural conditions and does not produce any persistent vegetative structures. In addition it does not survive in dry soils and requires optimal growth conditions, which include high soil moisture, for survival.

Related genera in the family *Scrophulariaceae* found in NSW and listed as noxious weeds are *Veronica arvensis* and *V. persica* (Persian speedwell), *Linaria dalmatica* syn *Antirrhinum dalmaticum* L., *Linaria grandiflora* Desf. (commonly known as Dalmatian toadflax) and *Verbascum thapsus* (commonly known as great mullein) (Holm et al. 1997; Parsons & Cuthbertson 2001).

SECTION 9 POTENTIAL FOR GENE TRANSFER

An extensive search of the scientific literature revealed no evidence of gene transfer occurring naturally between *Torenia* spp. and related plant species (den Nijs et al. 2004; Fischer 2004; AGBIOS 2005). In *Torenia*, gene transfer and hybridisation (by breeding) is possible between sexually compatible species (eg *T. fournieri* and *T. concolor*), which is the manner in which *T. X hybrida* was produced. In *T. X hybrida*, there is no mechanism for gene transfer between sexually compatible or incompatible species since this hybrid does not produce viable pollen or ovules.

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