Prospects for biological control of Chilean flame creeper *Tropaeolum speciosum* (Tropaeolaceae)

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Summary

Project and Client

The feasibility of biological control of Chilean flame creeper, *Tropaeolum speciosum*, in New Zealand has been investigated for a national collective comprised of regional councils and the Department of Conservation.

Objectives

- Record the distribution and weed status of *Tropaeolum speciosum* in New Zealand.
- Briefly assess the current control options in New Zealand.
- Review the literature, and current information available from researchers worldwide to detect potential agents for biological control of *Tropaeolum speciosum.*
- Assess the prospects of achieving successful biological control of *Tropaeolum speciosum* in New Zealand.
- Propose a realistically costed programme.

Methods

Information for this report was obtained by searching computer databases (CAB Abstracts, Current Contents) and internet sites; cross-referencing; and contact with regional council staff, biological control experts, botanists, plant pathologists, and entomologists in New Zealand and South America.

Main findings

- Chilean flame creeper is an invasive weed of increasing concern to regional authorities, particularly in the southernmost parts of New Zealand.
- The plant is a vigorous climber that smothers shrubs and trees, reducing light levels, and preventing regeneration of desirable species.
- Reproduction is both by seed contained in fleshy fruits dispersed by birds and vegetative, with new populations establishing readily from root fragments where garden waste has been dumped.
- Current control methods include uprooting by hand, cutting and painting stumps with herbicide, and foliar spraying with herbicide. Follow-up sprays with herbicides are recommended.
- The plant is extremely difficult to control because birds can deposit seed in isolated areas and vines can resprout readily from fragments of its large tuberous roots. In addition, there are potential non-target impacts of foliar sprays on native species because the vines are thin and spindly.
- In New Zealand, Chilean flame creeper shares the family Tropaeolaceae with two other naturalised species of *Tropaeolum*, *T. majus* (garden nasturtium) and *T. pentaphyllum*. There are no native species in this family.
- No invertebrates or pathogens have been recorded from Chilean flame creeper in New Zealand or elsewhere, including its native range in Chile.
- Systematic searches for potential biocontrol agents for Chilean flame creeper would be carried out in the Valdivian rain forest of Chile where it is endemic.

Conclusions

- Given the potential environmental impact of Chilean flame creeper, the ineffectiveness of current methods of control, and its taxonomic status in New Zealand, biocontrol is an appropriate strategy for controlling this weed.
- There are no indigenous Tropaeolaceae in New Zealand, so the main consideration for any prospective agents would be any impact on *Tropaeolum* species of value to the nursery industry or home gardeners.
- Systematic searches of Chilean flame creeper in its native range in Chile may reveal invertebrates and pathogens that have potential as classical biocontrol agents.
- If there are no potential classical biocontrol agents sufficiently host specific and damaging, then a bioherbicide approach might be feasible.

Recommendations

- Survey populations of Chilean flame creeper throughout its range in New Zealand to determine which invertebrates and pests are directly associated with damage to this species. Estimated cost: $50,000–$70,000.
- Survey the plant through its native range in Chile to identify prospective biocontrol agents (possibly in collaboration with SAG, Chile). Estimated cost: $60,000 over 2 years.
- On completion of the overseas survey, review the prospects for successful biocontrol of this species and, if appropriate, prepare a costed programme for consideration by the National Weed Biocontrol Collective.

1. Introduction

Chilean flame creeper, *Tropaeolum speciosum* Poepp. & Endl. (Tropaeolaceae), is an invasive climbing weed of disturbed forest and shrubland for which current control options are not adequate. As a result, the National Weed Biocontrol Collective funded Landcare Research, Auckland, to conduct a feasibility study into biological control of this weed.

2. Objectives

- Record the distribution and weed status of *Tropaeolum speciosum* in New Zealand.
- Briefly assess the current control options in New Zealand.
- Review the literature, and current information available from researchers worldwide to detect potential agents for biological control of *Tropaeolum speciosum.*
- Assess the prospects of achieving successful biological control of *Tropaeolum speciosum* in New Zealand.
- Propose a realistically costed programme for implementation by the National Weed Biocontrol Collective.

3. Methods

Information for this report was obtained by searching computer databases (CAB Abstracts, Current Contents, Worldweb Science, NZ Fungi Database, CABI Fungal database, USDA fungi, Ngā Tipu o Aotearoa – New Zealand Plants Database, USDA weeds database), and internet sites; by cross-referencing known references; and from:

Mr Richard Bowman, Biosecurity Manager, Environment Southland
Dr Rolf Delhey, Plant Pathologist, Universidad Nacional del Sur, Argentina
Dr Nicholas Martin, Entomologist, Crop & Food Research
Dr Sergio Rothmann, Entomologist, Servicio Agricola y Ganadero (SAG), Chile
Dr Carlos Villamil, Botanist, Universidad Nacional del Sur, Argentina
Dr Nicholas Waipara, Plant Pathology, Landcare Research

4. Results

4.1 Taxonomy and related species

Chilean flame creeper, *Tropaeolum speciosum* Poeppig & Endl., also known as flame flower and flame nasturtium, is a member of the Tropaeolaceae, a family of prostrate or climbing herbs comprising three genera: *Tropheastrum* (1 species, endemic to Patagonia), *Magallana* (2 species, endemic to Patagonia) and *Tropaeolum* (86 species ranging from southernmost Mexico to Chile and Argentina) (Sparre & Andersson 1991). The genus *Tropaeolum* is subdivided into two sections, *T.* section *Tropaeolum*, the species of which are distributed through the American tropics, and *T.* section *Chilensia*, which contains 22 species and 6 subspecies distributed in temperate South America, primarily in Chile (Andersson & Andersson 2000; Hershkovitz et al. 2006).

There are no indigenous genera or species in the Tropaeolaceae in New Zealand but three members of the genus *Tropaeolum* have naturalised: *T. majus* L. (garden nasturtium), *T. pentaphyllum* Lam. (ladies' legs), and *T. speciosum* (Chilean flame creeper) (Webb et al. 1988; Ngā Tipu o Aotearoa – New Zealand Plants Database, accessed via http://nzflora.landcareresearch.co.nz/). *T. pentaphyllum* has been placed, along with Chilean flame creeper, in *T.* section *Chilensia*. Both these species originate from the more temperate regions of South America. *T. majus*, on the other hand, is in *T.* section *Tropaeolum*, and is thought to have arisen as spontaneous hybrid in Peru (Sparre & Andersson 1991).

T. pentaphyllum, not commonly grown in cultivation, is mainly grown in the North Island (Webb et al. 1988). Its vegetative parts can easily be confused with those of Chilean flame creeper but the flowers can be readily distinguished. *T majus*, the garden nasturtium is very commonly cultivated with many cultivars (Webb et al. 1988). A number of varieties of *Tropaeolum* are sold through the nursery industry in New Zealand. There are 27 listings under *Tropaeolum* in Gaddum's Plantfinder 2000 (Gaddum 1990). These appear to be mostly varieties of *T. majus*, although possibly other species are used (listed as 'pentaphyllum', 'perigrinum', and 'tricolorum' in Gaddum's Plantfinder 2000).

4.2 Distribution and weed status of Chilean flame creeper in New Zealand

Chilean flame creeper is a climbing perennial vine that can reach at least 10 m into tree canopies. Its thin wiry stems have coiling tendrils that attach to supporting vegetation. The blue-green five- to six-fingered leaves are thin and fleshy and die off over winter. The fleshy stoloniferous, below-ground rhizomes re-sprout each spring. Scarlet tubular flowers, about 15 mm across, are found through spring and summer (November–April). Fruiting occurs from December to March, with the seed contained in fleshy blue-black berries that are about 1 cm wide.

Chilean flame creeper can climb vigorously in full sun, and grows best in fertile, well-drained soil. It can tolerate a wide range of environmental conditions including warm to cold, salt, wind, damp and drought. The seeds are effectively dispersed by birds eating the berries. The vine can also replicate vegetatively through its tuberous root system.

Chilean flame creeper is endemic to Chile, occurring from Concepción and Nuble province to the northern part of Aysén province. It is restricted to the coastal Valdivian rain forest, growing in *Nothofagus* forest and *Chusquea* thickets. Sparre and Anderson (1991) describe it as 'rather common in both the coastal area and in the Cordillera where it reaches about 1000m altitude'. However, Sergio Rothmann, SAG Chile, says that various entomologists and botanists in Chile 'agreed it is not a common species in the forest' when he made enquiries recently (pers. comm.).

Chilean flame creeper was first recorded as naturalised in New Zealand in 1958 (Webb et al.1988). In the North Island, small scattered populations occur as far north as the Waikato Region, where there is a limited number of sites, mostly in the Northern King Country. In the South Island it occurs as far south as Southland and inland from the coast to the Craigieburn intermontaine region of Canterbury (Webb et al. 1988). It is also present on Stewart Island.

Originally an escape from garden cultivation in New Zealand, Chilean flame creeper now occurs typically in disturbed forest and shrublands. It has become more invasive in recent years, especially in Southland where it has been described as 'flourishing' and 'uncontrollable' (Richard Bowman, pers. comm.) and it has been reported as doing very well in Southland and Stewart Island after the 1996 frosts. The vine suppresses and replaces native vegetation by shading and smothering. This is of particular concern should it invade the habitat of endangered species where it can either displace endangered plant species or reduce food resources for endangered animal species. The ability of birds to spread the seed to remote locations where the plants may not be detected contributes to its invasiveness. Chilean flame creeper has the ability to resprout from fragments of its tuberous roots system and consequently is spread by the dumping of garden waste and by soil movements. It can restrict access in areas of heavy infestation adversely affecting amenity values. Environment Waikato, which is currently undertaking direct control with the Department of Conservation, has estimated that the "do nothing" option for control would result in identifiable damage to Regional conservation values in over 5265 hectares.

Chilean flame creeper is listed as an Unwanted Organism on the National Pest Plant Accord (NPPA) list which makes it illegal to sell, propagate or distribute the plant under the Biosecurity Act. It also appears in the Regional Pest Management Strategies (RPMS) from the following Regional Councils (see Appendix for websites):

- Environment Southland – a total control plant on Stewart Island, a surveillance plant in the rest of the region;
- Greater Wellington Regional Council – identified for Key Ecosystem Management, i.e. controlled in some special places;
- Horizons Regional Council – Regional Surveillance Plant;
- Environment Waikato – Eradication (Service Delivery) Plant.

4.3 Current control options

T. speciosum is extremely difficult to eradicate because new vines re-sprout from the root, requiring ongoing follow-up work. The optimum control time is from spring through summer (September–February).

Plants can be controlled physically by tracing stems to the ground and digging up the roots. Care must be taken as the plant can re-grow from relatively small root fragments, and stems in contact with the ground may also form new roots. Root fragments remaining in the ground

may need to be treated with herbicide where possible. Plant material can be disposed of by burning or drying out in the sun. Aerial parts may be composted following removal of seeds or fruit, but root material should not be composted. The safest method of disposal is deep burial in a landfill. This method is more suited to smaller plants. An alternative method is to cut the vines and treat the stems or stumps with herbicide.

There are no completely effective chemical control methods known, however, the following treatments have been suggested by regional councils. Tordon Brushkiller (3 ml/L) and Glyphosate (20 ml/L) with a penetrant may be used for foliar spraying. This should be done during spring–summer because the plant loses its leaves during winter. A 6-monthly follow-up is recommended to deal with any re-sprouting that occurs from the root stock. Because the vines are thin and spindly and scramble over other vegetation, non-target spraying is an issue with this treatment method. Cut stems or stumps can be swabbed with either glyphosate (50%), Escort (5 g/L), or Tordon Brushkiller (25–35%). This treatment may be used all year round.

The above information was supplied from Environment Southland, Christchurch City Council, Horizons Regional Council, and Auckland Regional Council websites (see Appendix).

4.4 Potential agents for biological control of Chilean flame creeper

No invertebrates have been recorded from Chilean flame creeper in New Zealand (Spiller & Wise 1982). A systematic survey would probably reveal herbivorous insects feeding on the plant in New Zealand; however, they may not be causing significant damage to the plant. There are no records of plant diseases on Chilean flame creeper (NZ Fungi Database, http://nzfungi.landcareresearch.co.nz), but again surveys are likely to find some.

There are no records of invertebrates from Chilean flame creeper in the literature (CAB Abstracts 1910–2006, Current Contents, Web of Science). Sergio Rothmann (an entomologist with SAG, Chile) is unaware of any studies of arthropods associated with this species, and after consulting other Chilean entomologists and botanists reports there are no records of invertebrates on this plant. Moreover, no-one could recall any particular damage by invertebrates to the plant, which they agreed was not a common species in its native range. Similarly, there are no records of pathogens on Chilean flame creeper outside New Zealand including the native range (Viégas, 1961; Sergio Rothmann, pers. comm.; Rolf Delhey, pers. comm.; SBML Fungal database; CABI Bioscience Database; CAB Abstracts).

There are records of invertebrates and pathogens on other species of Tropaeolaceae in New Zealand and elsewhere (see Appendix) (Spiller & Wise 1982; Plant-SyNZ database; NZ Fungal database, SBML Fungal database; CABI Bioscience Database; CAB Abstracts). In New Zealand, the cabbage white butterfly, a moth and three leafmining flies have been recorded feeding on *T. major* (nasturtium). All are known to utilise other plant species, with several feeding on brassicas. Most invertebrate records in the international literature are for polyphagous species that feed on *T. major* (nasturtium), in particular the large white butterfly, *Pieris brassica*, leaf-mining flies *Liriomyza* spp. (Agromyzidae), and several aphid species.

Some species of damaging disease pathogens have been recorded on related members of the family (see Appendix). While many of these may be specific to the reported associated host(s), some could be scoped for either inundative or classical biocontrol agents if no

appropriate diseases are found on the target in its native range. For example, *Glomerella cingulata* (recorded from *T. majus*, Brunei and Borneo) and *Sclerotinia* sp. (recorded from *T. majus* in Uganda and Korea) have potential as inundative biocontrol agents (bioherbicides), and *Uredo tropeaoli* (recorded from *T. aduncum* in the UK) has potential as a classical biocontrol agent (Nick Waipara, pers. comm.) However, as most are recorded on *T. majus*, there could be unacceptable non-target impacts on the cultivated relative.

4.5 Prospects for achieving biological control of Chilean flame creeper through biological control

No potential biocontrol agents for Chilean flame creeper have been identified, including in its native range in Chile. It is interesting that researchers in Chile have reported that the plant is not a common species (Sergio Rothmann, pers. comm.), when it is invasive in parts of New Zealand, especially in the south where there is much concern about its potential to smother native bush. Even though little invertebrate damage has been observed, invertebrates and pathogens may contribute to Chilean flame creeper not being common in its native range. A systematic search could reveal potential agents with sufficient host specificity and would be worth pursuing given the inadequacy of current control methods in New Zealand.

Host-range testing is important to minimize the risk of damage to valued non-target plants. If there are no native plants or plants of economic significance in the same family, then the chances of finding agents with a suitable degree of host specificity are enhanced. The prospects of finding agents that will not impact on native New Zealand plants therefore look good as there are none in the Tropaeolaceae. The only members of Tropaeolaceae naturalized in New Zealand other than Chilean flame creeper are *T. pentaphyllum* (ladies legs) and *T. majus*, the garden nasturtium. *T. pentaphyllum* is the most closely related to Chilean flame creeper, with both species occurring in the same section of *Tropaeolum* (*Chilensia*). *T. majus*, although in the same genus, is less related, occurring in a different section. A number of ornamental 'species' of *Tropaeolum* are cultivated by nurseries and home gardeners (Gaddum 1999) and any impact of potential biocontrol agents on these plants would need to be considered. A host test list would also need to consider members of other closely related families in New Zealand including some ornamentals and brassicas. If there are no suitable candidates for classical biocontrol and if suitable pathogens are present in New Zealand, then a bio-mycoherbicide could be considered, although this would have a high development cost.

5. Conclusions

Chilean flame creeper has the potential to be a serious invasive weed in New Zealand and is of particular concern currently in the southernmost parts of the country. It invades disturbed forest and shrubland, and can tolerate a wide variety of environmental conditions. Its climbing vines smother native vegetation and alter light levels, thus preventing recruitment of desirable species, as does its thick tuberous roots. Its fruit is readily dispersed to new areas by birds and it is difficult to eradicate by physical or chemical means because new vines resprout from root fragments. Chilean flame creeper belongs to the family Tropaeolaceae, (which is from Central and South America), and is endemic to the Valdivian rain forest in Chile. Two other species from the Tropaeolaeceae, *T. majus* (the garden nasturtium) and *T. pentaphyllum*, are naturalized in New Zealand. *T. majus* is in a separate section of the genus.

Given the potential impact of Chilean flame creeper, the ineffectiveness of current methods of control, and its taxonomic status in New Zealand, biological control is an appropriate strategy for controlling this weed. The main consideration would be any impact of potential agents on *Tropaeolum* species of value to the nursery industry or home gardeners as these are the most likely to be affected. There are no recorded invertebrates or diseases on Chilean flame creeper in New Zealand or elsewhere, including its native range. However, systematic surveys in the native range may reveal potential biocontrol agents that are sufficiently host specific for biological control of Chilean flame creeper in New Zealand.

6. Recommendations

- Survey populations of Chilean flame creeper throughout its range in New Zealand to determine which invertebrates and pests are directly associated with damage to this species. Estimated cost: $50,000–$70,000.
- Survey the plant through its native range in Chile to identify prospective biocontrol agents (possibly in collaboration with SAG, Chile). Estimated cost: $60,000 over 2 years.
- On completion of the overseas survey, review the prospects for successful biocontrol of this species and, if appropriate, prepare a costed programme for consideration by the National Weed Biocontrol Collective.

7. Acknowledgements

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Appendix 1 Invertebrates recorded on Tropaeolaceae in New Zealand

Invertebrate species	Associated host plant	Reference
Epyaxa rosearia Geometrid moth - endemic Larvae feed on foliage	*Tropaeolum majus* (and native species)	Plant-SyNZ (N.A. Martin) (also in Spiller & Wise 1982)
Liriomyza brassicae Agromyzid fly – adventive Larvae mine leaves	*T. majus* (also Brassicaceae)	Plant-SyNZ (N.A. Martin)
Liriomyza watti Agromyzid fly – endemic Larvae mine leaves	*T. majus* (also Brassicaceae)	Plant-SyNZ (N.A. Martin)
Pieris rapae Cabbage white butterfly Polyphagous species	*Tropaeolum majus*	Spiller & Wise 1982
Scaptomyza flava Drosophilid fly – adventive Larvae mine leaves	*Tropaeolum majus* (also Brassicaceae and other species)	Plant-SyNZ (N.A. Martin)

Appendix 2 Pathogens recorded on Tropaeolaeceae in New Zealand

Pathogen	Associated host plant	Reference
Acroconidiella tropaeoli	*Tropaeolum majus*	*NZ Fungi database
Broad bean wilt virus 1	*T. majus*	NZ Fungi database
Coleosporium tropaeoli (rust from Germany, not New Zealand – stored in ICMP)	*Tropaeolum peregrinum*	NZ Fungi database
Pseudomonas syringae	*T. majus*	NZ Fungi database
Tomato spotted wilt virus	*T. majus*	NZ Fungi database
Turnip mosaic virus – TuMV (economically important virus)	*T. majus*	Tang et al. 2006
Verbena latent carlavirus – VeLV	*T. majus*	Tang et al. 2006
Unidentified tentative *Carmovirus*	*T. majus*	Tang et al. 2006

*Landcare Research's NZ Fungi Database (http://nzfungi.landcareresearch.co.nz):

Tang JZ, Ochoa-Corona FM, Lebas BSM, Elliot DR, Thangevel R, Alexander BSJ 2006. Detection of four viruses in *Tropaeolum majus* in New Zealand. New Zealand Plant Protection Society Conference.

Appendix 3 Invertebrates recorded on Tropaeolaceae outside New Zealand

CAB Abstracts (1910–2006):

Invertebrate	Associated host plant	Location (Reference)
Aphis abbreviate (buckthorn aphid)	Many cultivated and wild plants worldwide including nasturtium	US (Patch 1924)
Aphis barberae (aphid)	*T. majus* and burdock (*Arctium minus*)	Canada (Robinson 1980)
Aphis fabae (black bean aphid) subspecies *mordwilkoi* And other clones	*T. majus* (and *Rumex obtusifolius*) And other species	UK (Tosh et al. 2004) Germany (Scholze P 1992, Muller 1988) UK (Douglas 1997)
Athalia proxima (mustard sawfly)	Crucifers and a number of noncrucifers (Cruciferae and Tropaeoalaceae) *Tropaeolum* sp.	India (Sehgal et al. 1975)
Brevicoryne brassicae (cabbage aphid)	*T. majus*, *Brassica oleracea* (cabbage)	Netherlands (Tjallingii 1976)
Chromatomyia horticola (agromyzid leaf-mining fly) Polyphagous	*T. majus*	India (Singh & Bhati 1996)
Globodera spp. (nematode pest of potatoes)	*T. tubersosum* – 1 of 27 lines tested acted as a trap crop for *Globodera* spp.	Bolivia (Main et al. 1999)
Hyposchila galactodice (Patagonian-Fuegian white butterfly)	*Trophaeolum incisum* = natural food plant but could be reared on cruciferous weeds	Western Patagonia, Argentina (Shapiro 1990)
Leptophobia aripa (pierid butterfly)	*T. majus* Defoliates host plant	Argentina (Neder de Roman et al. 1983)
Liriomyza brassicae (agromyzid fly)	*T. majus*, *T. minus* Also on *Brassica* spp. Infests various cruciferous plants and nasturtium (US, Canada and Hawaii)	India (Udayagiri 1987, Gokulpure 1975) Argentina (Valladares 1984) Frick 1957
Liriomyza huidobrensis (agromyzid leaf-mining fly) Important pest species	Wild plants and Tropaeolum	Costa Rica (Spencer 1983)
Myzus persicae (green peach aphid)	*T. majus* And other hosts?	US (Barker et al. 1951)
Nematode pests	*Tropolaeum tuberosum* (mashua)	Tropical and subtropical agriculture (Bridge et al. 2005, Jatala & Bridge 1990)
Pieris brassicae (large white butterfly) Polyphagous	*T. majus*	Estonia (Jogar et al. 2005, Metspalu et al. 2003), Chile (Angulo et al. 1982)

Invertebrate	Associated host plant	Location (Reference)
Pieris rapae (white butterfly) Polyphagous	*T. majus*	USA (Renwick et al. 1999, 1995) India (Sood & Kakar 1990) New Zealand (Ferguson 1975)
Plutella xylostella (diamondback moth) polyphagous	*T. majus*	Japan (Habu et al. 1995)
Trialeurodes vaporariorum (greenhouse whitefly) polyphagous pest	*Tropolaeum majus*	China (Ma et al. 2005)

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Appendix 4 Pathogens recorded on Tropaeolaceae worldwide

*SBML Fungus-Host Database 13 July 2006:

Pathogen	Associated host plant	Location
Acroconidiella tropaeoli	*Tropaeolum majus*	Australia, Azores, California, India, New Zealand, Papua New Guinea, South Africa
	Tropaeolum sp.	California, Hawaii
Alternaria sp.	*T. majus*	California, Korea
Alternaria tropaeoli	*T. majus*	India
Alternaria tropaeolicola	*T. majus*	China
Ascochyta sp.	*T. majus*	India
Botrytis cinerea	*T. majus*	Alaska
Cercospora tropaeoli	*T. majus*	Alabama, Texas, Uganda
Cladosporium macrocarpum	*T. majus*	China
Cladosporium sp.	*T. majus*	California
Coelosporium sp	*Tropaeolum minus*	Sweden
	Tropaeolum peregrinum	Sweden
Coleosporium tussilaginus	*T. peregrinum*	UK
Cronartium flaccidum	*T. majus*	UK
	T. minus	Sweden
Didymosphaeria sarmenti	*T. peregrinum*	California
	Tropaeolum sp.	California
Glomerella cingulata	*T. majus*	Brunei
Heterosporium tropaeoli	*T. majus*	California, Hawaii, Kenya, New York
Leveillula taurica	*T. majus*	Australia, Barbados, Canary Islands, China, Egypt, Ethiopia, France, India, Indonesia, Iran, Iraq, Israel, Italy, Kenya, Madagascar, Malawi, Mauritius, Morocco, Mozambique, Myanmar, New Caledonia, Pakistan, Portugal, Saudi Arabia, Senegal, South Africa, Southern Africa, Sudan, Tanzania, Turkey, Zambia, Zimbabwe
	T. minus	Morroco
	T. pentaphyllum	India
	Tropaeolum sp.	Ethiopia, Greece, India, Italy, Mauritius, South Africa
Leveillula tropaeoli	*T. majus*	China
Myrothecium roridum	*T. majus*	California, Denmark
	Tropaeolum sp.	California
Oidiopsis sicula	*T. major*	Ethiopia

Pathogen	Associated host plant	Location
	Tropaeolum sp.	Ethiopia
Oidiopsis sp.	*T. majus*	Barbados, China, New Caledonia
Oidiopsis taurica	*T. majus*	Australia, New Caledonia, South Africa
Oidium sp.	*T. majus*	Australia, India, Kenya, Madeira Islands, New Caledonia, Sri Lanka, Uganda
	T. pentaphyllum	Argentina, India
	Tropaeolum sp.	Uganda
Ovulariopsis sp.	*T. majus*	Venezuela
Phyllosticta sp.	*T. majus*	Wisconsin
Pleospora sp.	*T. majus*	Mississippi, New Jersey, Ohio
Pleospora tropaeoli	*T. majus*	Oklahoma, Southern Africa, Zimbabwe
Pseudomonas solanacearum	*T. majus*	South Africa
Puccinia aristide	*T. majus*	Utah
Pythium sp.	*T. majus* (root rot)	Hawaii, Scotland
Pythium ultimum	*T. majus*	South Africa
Rhizoctonia solani	*T. majus* (root rot)	Florida
Septoria sp.	*T. majus*	Korea
Sphaeria sarmenti	*T. minus*	California
Stemphylium sp.	*T. majus*	Venezuela
Uredo tropaeoli	*Tropaeolum aduncum*	UK
	T. majus	Bulgaria

*Farr DF, Rossman AY, Palm ME, McCray EB (n.d.) Fungal Databases, Systematic Botany & Mycology Laboratory, ARS, USDA. Retrieved 13 July, 2006, from http://nt.ars-grin.gov/fungaldatabases/

CABI Bioscience database 15 July 2006:

Pathogen	**Associated organism**	**Location**
Acroconidiella tropaeoli	*Tropaeolum* sp.	Jamaica, Mauritius, Papua New Guinea, Uttaranchal
Acroconidiella tropaeoli	*Tropaeolum majus*	Australia, Azores, Buenos Aires, Ethiopia, Great Britain, Haiti, India, Jamaica, New Zealand, Sri Lanka, Tanzania, Uganda
Alternaria	*T. majus*	West Bengal
Aspergillus awamori	*Tropaeolum* (associated with rhizosphere)	Egypt
Aspergillus flavus	*Tropaeolum* sp.	Egypt
Aspergillus terreus	*Tropaeolum* sp.	Egypt
Cercosporia tropaeoli	*T. majus*	West Bengal
Cercospora tropaeoli	*Tropaeolum*sp.	Zambia
Cladosporium	*T. majus*	West Bengal
Coleosporium tussilaginus	*Tropaeolum peregrinum* (on leaf)	Great Britain
Colletotrichum capsici	*T. majus*	India
Fusarium solani	*Tropaeolum* sp.	Egypt
Glomerella cingulata	*T. majus*	Borneo
Humicola fuscoatra	*Tropaeolum* sp.	Egypt
Leveillula taurica	*T. majus*	Ethiopia, India, Kenya, Mauritius, Tanzania, Zambia,
Leveillula taurica	*Tropaeolum* sp.	Kenya, Madhya Pradesh, Sudan, Zimbabwe
Leveillula taurica	*Tropaeolum pentaphyllum*	Jammu & Kashmir, India
Penicillium funiculosum	*Tropaeolum* sp.	Egypt
Phyllosticta	*T. majus*	Pakistan
Pleospora tropaeoli	*T. majus*	Kenya
Oidium	*T. majus*	Kenya
Sclerotinia	*T. majus*	Uganda
Thielavia	*Tropaeolum* sp.	Egypt

Appendix 5 Selection of websites containing information on Chilean flame creeper in New Zealand

Auckland Regional Council
http://www.arc.govt.nz/arc
(accessed 15 July 2006)

Biosecurity New Zealand:
– pest and diseases watchlist
http://www.biosecurity.govt.nz/pest-and-disease-response/pests-and-diseases-watchlist/chilean-flame-creeper
– National Pest Plant Accord August 2001
http://www.biosecurity.govt.nz/pests-diseases/plants/accord.htm
(accessed 31 March 2006)

Christchurch City Council
http://www.ccc.govt.nz/parks/TheEnvironment/WeedGuide/PDF/Mar2003.pdf
(accessed 31 March 2006)

Environment Southland
http://www.es.govt.nz/Departments/Biosecurity
(accessed 15 July 2006)

Environment Waikato – Regional Pest Management Strategy 2002-2007 – Plant pest
http://www.ew.govt.nz/policyandplans/rpmsintro/rpms2002/operative5.2.3.htm
(accessed 31.March 2006)

Greater Wellington Regional Council
http://www.govt.nz
(accessed 15 July 2006)

Horizons Regional Council
http://www.horizonsmw.govt.nz/images/Chilean%20Flame%20Creeper.pdf
(accessed 31 March 2006)