Cronartium Rusts Sporulate on a Wide Range of Alternate Hosts in Northern Europe

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INTRODUCTION

Cronartium flaccidum is a serious pathogen of two-needle pines, especially of *Pinus sylvestris*, in northern Fennoscandia (Samils et al. 2010). The rust spreads via a number of alternate hosts in natural forests and gardens, among which species in genera *Melampyrum, Pedicularis*, *Vincetoxicum*, and *Paeonia* are the most important known ones (Gäumann 1959; Kaitera et al. 1999). In northern Europe, the most important species is *Melampyrum sylvaticum* (Kaitera et al. 2005), while in southern Europe the respective species is *Vincetoxicum hirundinaria* (Gäumann 1959). *Cronartium ribicola* is a common pathogen on five-needle pines in arboretums, botanical gardens, and parks in northern Europe (Gäumann 1959; Kaitera et al. 2013). The rust spreads mainly via *Ribes* (Kaitera and Nuorteva 2006).

METHODS

To test the susceptibility of known and potential alternate hosts to *C. flaccidum* and *C. ribicola*, 109 plant species in 18 families were inoculated using various Fennoscandian spore sources in 2008–2013. The inoculations were performed in the greenhouse and in the laboratory, and plants were also exposed to natural inoculum in the field (e.g., Kaitera et al. 2015).

RESULTS AND DISCUSSION

Over the years, 45 plant species in 13 families supported uredinial or telial sporulation of *C. flaccidum* on tested leaves, while *C. ribicola* sporulated on 16 species or cultivars in 5 families (Kaitera and Hiltunen 2011, 2012; Kaitera et al. 2012, 2015). Among the tested species, hemiparasites were highly susceptible to both rusts. All of the tested genera of family Orobanchaceae included species that were susceptible to *C. flaccidum* in the greenhouse and in the laboratory. Some of these species were also infected when exposed to natural inoculum in the field (Kaitera et al. 2015).

Cronartium ribicola sporulated on species in genera such as *Bartsia* (fig. 1), *Castilleja* (fig. 2), *Pedicularis* (fig. 3), *Mentzeli*a (fig. 4), *Loasa* (fig. 5), *Tropaeolum* (fig. 6) and *Ribes* (figs. 7–9). *Cronartium flaccidum* sporulated on species in genera such as *Melampyrum* (figs. 10–13), *Pedicularis* (figs. 14–17), *Rhinanthus* (figs. 18–19), *Euphrasia* (figs. 20–23), *Loasa* (figs. 24–25), *Bartsia* (fig. 26), *Impatiens* (figs. 27–28), *Vincetoxicum* (fig. 29), *Asclepias* (fig. 30), *Apocynum* (fig. 31), *Nicotiana* (fig. 32), *Swertia* (fig. 33), *Veronica* (figs. 34–38), *Nemesia* (figs. 39–40), *Paeonia* (figs. 41–45), *Tropaeolum* (fig. 46), *Verbena* (figs. 47–48), *Saxifraga* (figs. 49–50), *Castilleja* (fig. 51) and *Myrica* (fig. 52).

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In conclusion, a high number of previously unknown alternate hosts can support rust sporulation under laboratory and greenhouse conditions, as well as in the field, and therefore, may also spread rust epidemics under favorable conditions in natural forests.

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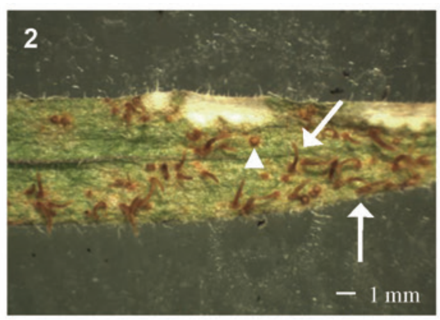
Figure 1–52—(1) Uredinia (white arrow heads) and telia (white arrows) of *Cronartium ribicola* (nos. 1-9) and *C. flaccidum* (nos. 10–52) on abaxial leaf surface of the plants.



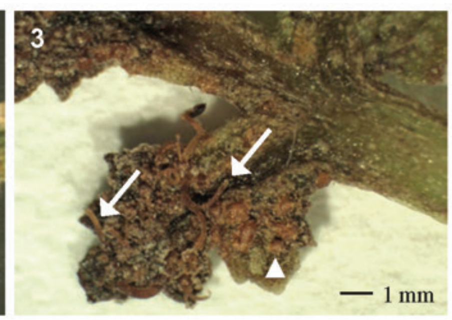
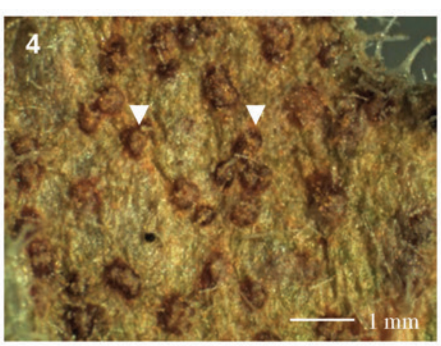
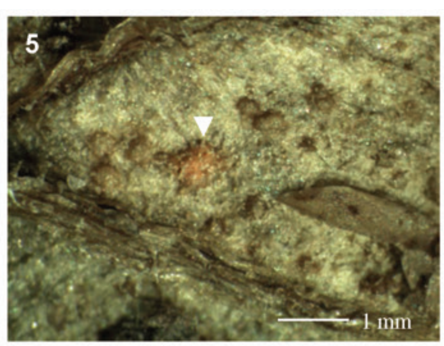


Figure 1—Uredinia of *Cronartium ribicola* on *Bartsia alpina*.
Figure 2—Uredinia and telia of *C. ribicola* on *Castilleja sulphurea*.
Figure 3—Uredinia and telia of *C. ribicola* on *Pedicularis palustris* ssp. *palustris*.





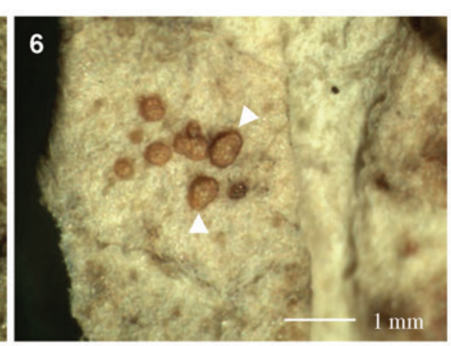


Figure 4—Uredinia of *C. ribicola* on *Mentzelia lindleyi*.
Figure 5—Uredinia of *C. ribicola* on *Loasa triphylla*.
Figure 6—Uredinia of *C. ribicola* on *Tropaeolum majus*.

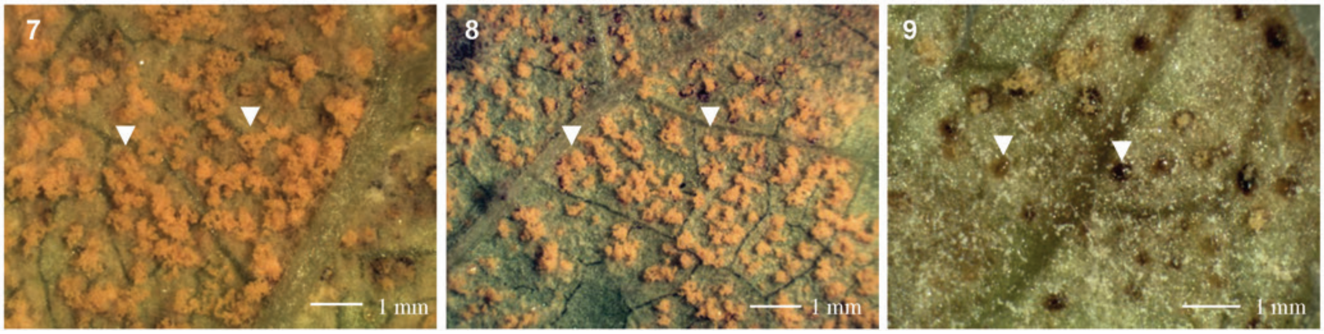


Figure 7—Uredinia of *C. ribicola* on *Ribes nigrum* ‘Mortti’.
Figure 8—Uredinia of *C. ribicola* on *Ribes spicatum* subsp. *spicatum.*
Figure 9—Uredinia of *C. ribicola* on *Ribes laxiflorum*.

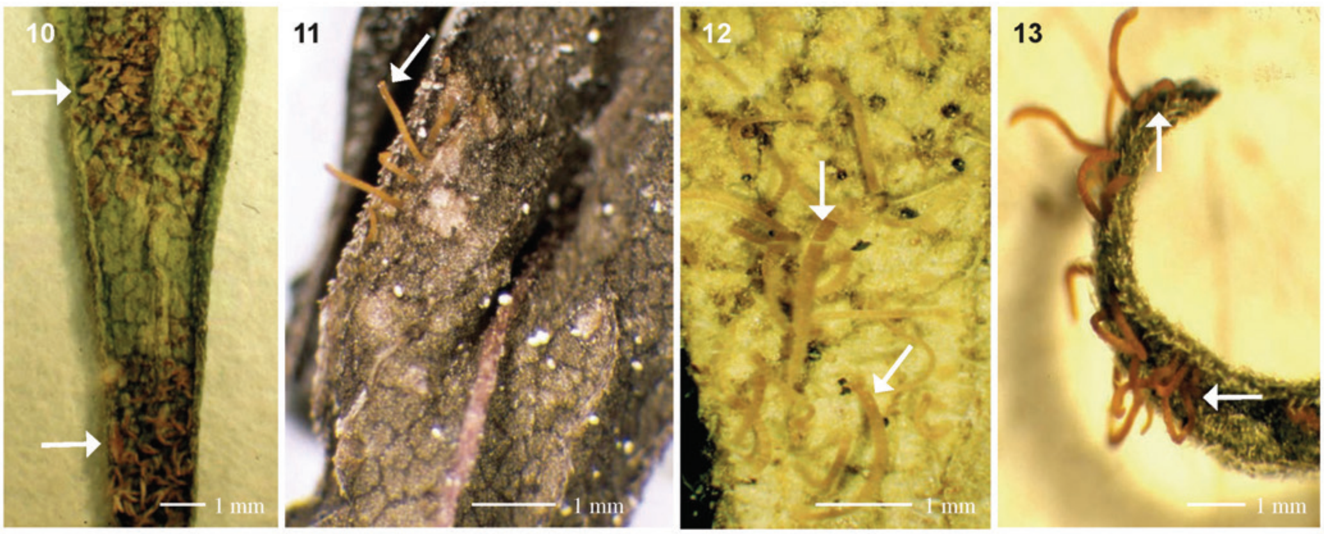


Figure 10—Telia of *Cronartium flaccidum* on *Melampyrum sylvaticum*.
Figure 11—Telia of *C. flaccidum* on *Melampyrum pratense*.
Figure 12—Telia of *C. flaccidum* on *Melampyrum nemorosum*.
Figure 13—Telia of *C. flaccidum* on *Melampyrum arvense*.

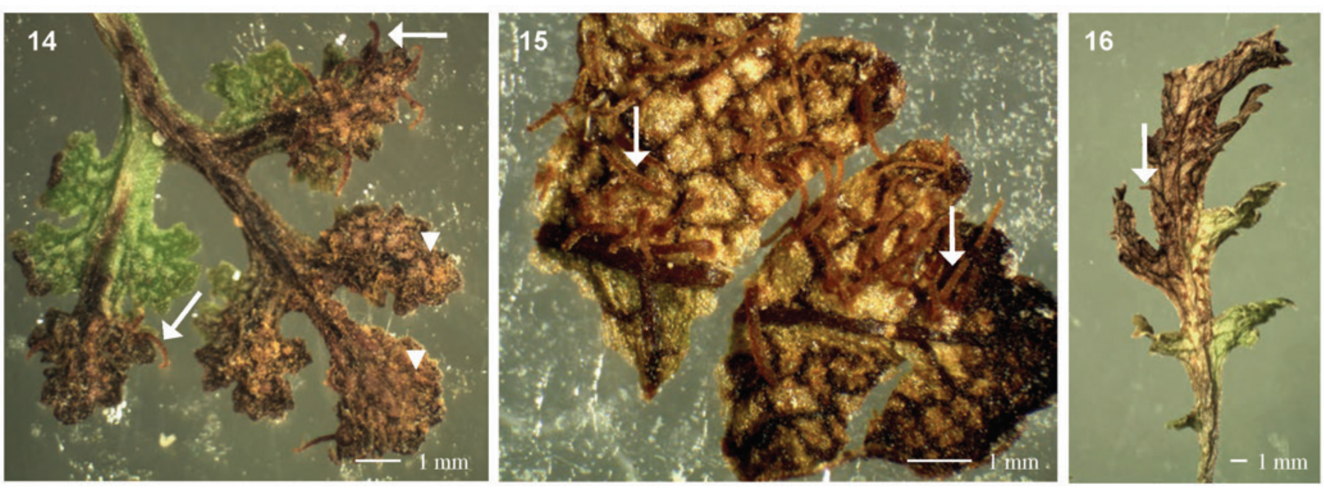
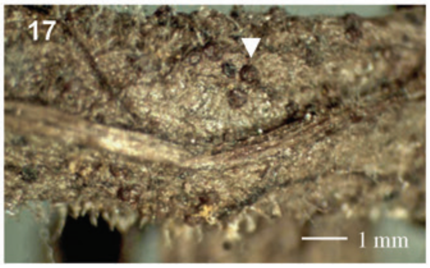
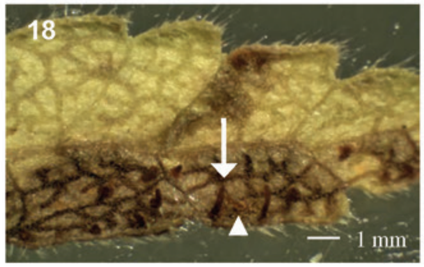


Figure 14—Uredinia and telia of *C. flaccidum* on *Pedicularis palustris* ssp. *palustris*.
Figure 15—Telia of *C. flaccidum* on *Pedicularis sceptrum-carolinum*.
Figure 16—Telia of *C. flaccidum* on *Pedicularis groenlandica*.





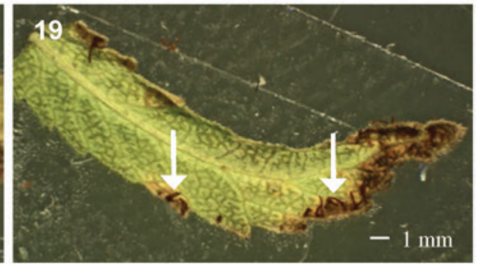
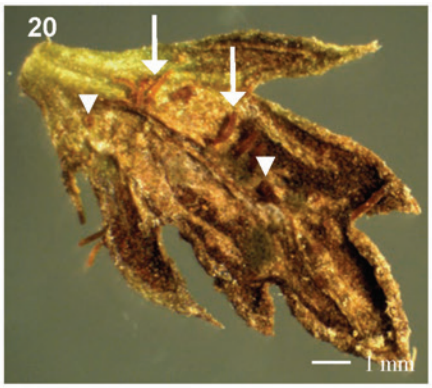
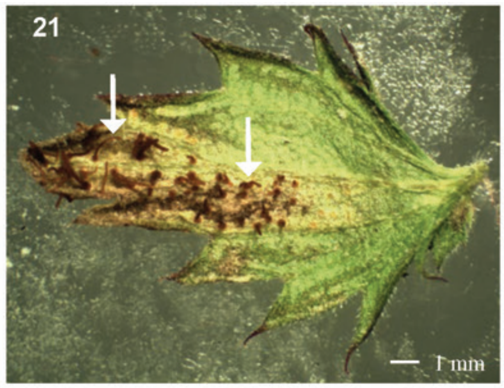


Figure 17—Uredinia of *C. flaccidum* on *Pedicularis dolichorrhiza*.
Figure 18—Uredinia and telia of *C. flaccidum* on *Rhinanthus minor*.
Figure 19—Telia of *C. flaccidum* on *Rhinanthus aestivalis*.





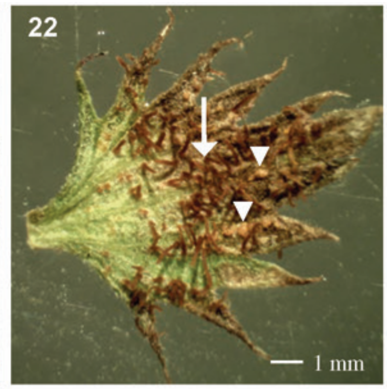
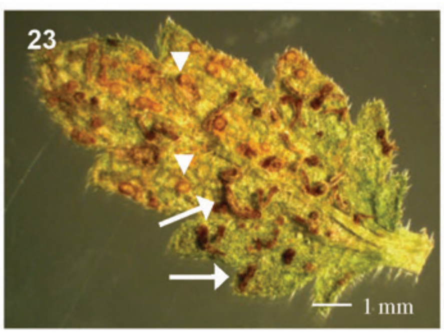
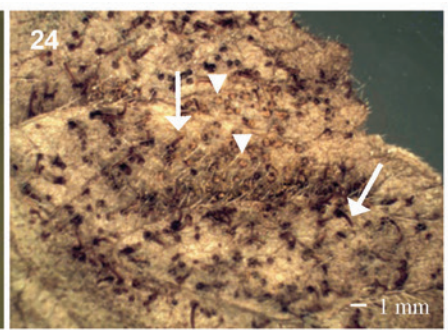


Figure 20—Uredinia and telia of *C. flaccidum* on *Euphrasia minima*.
Figure 21—Telia of *C. flaccidum* on *Euphrasia brevipila*.
Figure 22—Uredinia and telia of *C. flaccidum* on *Euphrasia stricta*.





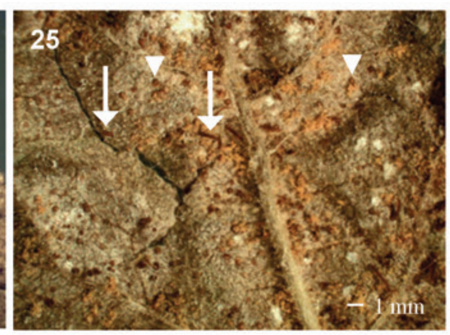


Figure 23—Uredinia and telia of *C. flaccidum* on *Euphrasia officinalis*.
Figure 24—Uredinia and telia of *C. flaccidum* on *Loasa tricolor*.
Figure 25—Uredinia and telia of *C. flaccidum* on *Loasa triphylla*.

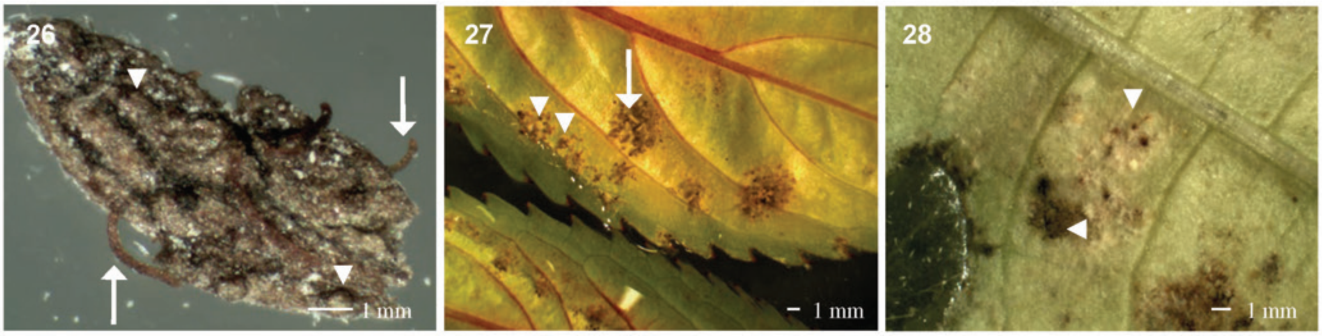


Figure 26—Uredinia and telia of *C. flaccidum* on *Bartsia alpina*.
Figure 27—Uredinia and telia of *C. flaccidum* on *Impatiens balsamina*.
Figure 28—Uredinia of *C. flaccidum* on *Impatiens glandulifera*.

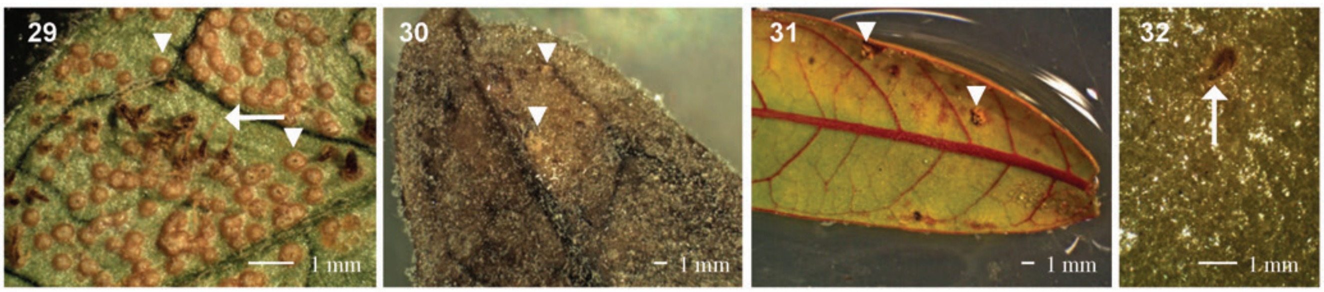


Figure 29—Uredinia and telia of *C. flaccidum* on *Vincetoxicum hirundinaria*.
Figure 30—Uredinia of *C. flaccidum* on *Asclepias incarnata*.
Figure 31—Uredinia of *C. flaccidum* on *Apocynum cannabinum*.
Figure 32—Telium of *C. flaccidum* on *Nicotiana rustica*.

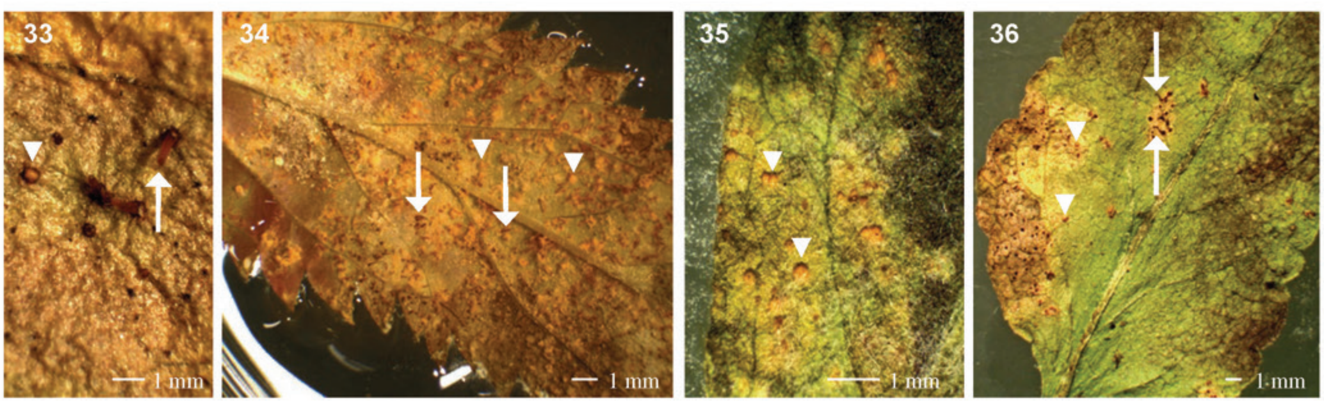


Figure 33—Uredinia and telia of *C. flaccidum* on *Swertia fedtschenkoana*.
Figure 34—Uredinia and telia of *C. flaccidum* on *Veronica longifolia*.
Figure 35—Uredinia of *C. flaccidum* on *Veronica incana*.
Figure 36—Uredinia and telia of *C. flaccidum* on *Veronica krylovii*.

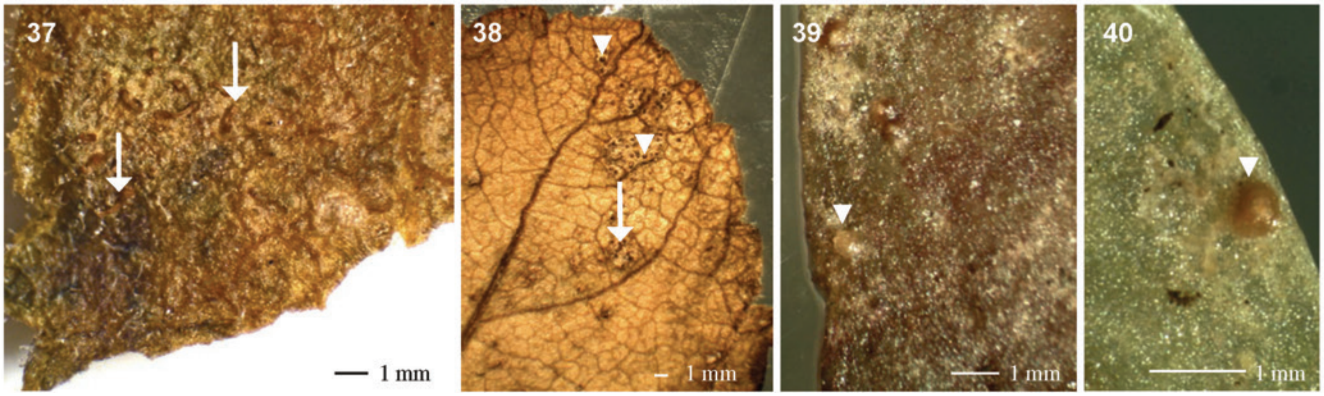


Figure 37—Telia of *C. flaccidum* on *Veronica daurica*.
Figure 38—Uredinia and telia of *C. flaccidum* on *Veronica grandis*.
Figure 39—Uredinia of *C. flaccidum* on *Nemesia versicolor*.
Figure 40—Uredinium of *C. flaccidum* on *Nemesia strumosa*.

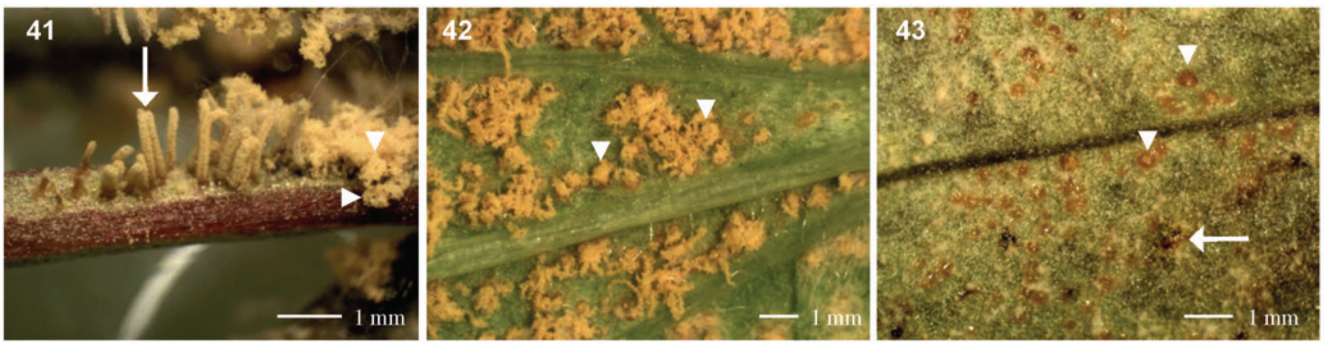


Figure 41—Uredinia and telia of *C. flaccidum* on *Paeonia tenuifolia*.
Figure 42—Uredinia of *C. flaccidum* on *Paeonia officinalis*.
Figure 43—Uredinia and telia of *C. flaccidum* on *Paeonia lactiflora*.

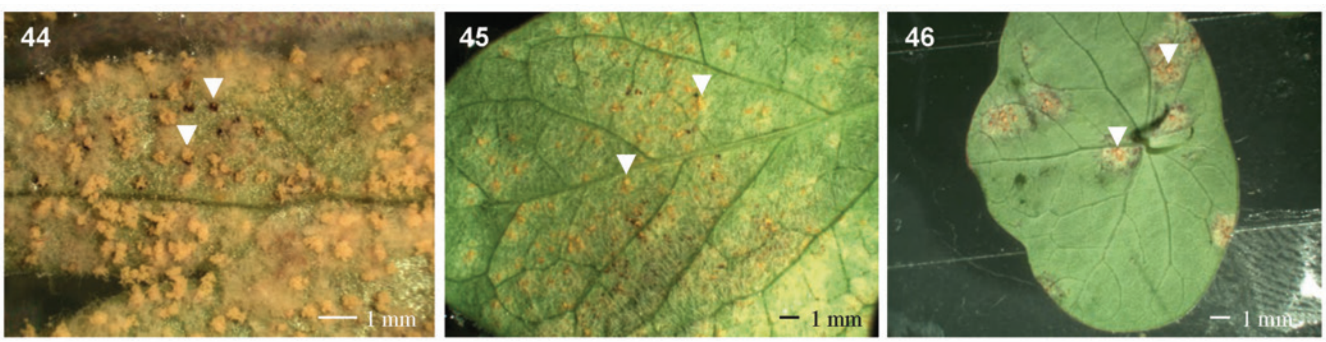


Figure 44—Uredinia of *C. flaccidum* on *Paeonia anomala*.
Figure 45—Uredinia of *C. flaccidum* on *Paeonia obovata*.
Figure 46—Uredinia of *C. flaccidum* on *Tropaeolum majus*.

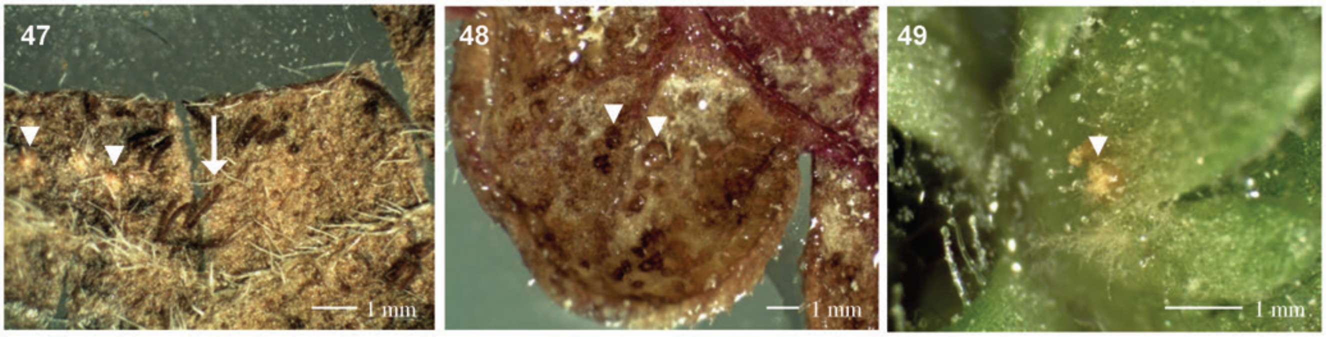


Figure 47—Uredinia and telia of *C. flaccidum* on *Verbena canadensis*.
Figure 48—Uredinia of *C. flaccidum* on *Verbena x hybrida*.
Figure 49—Uredinia of *C. flaccidum* on *Saxifraga exarata*.

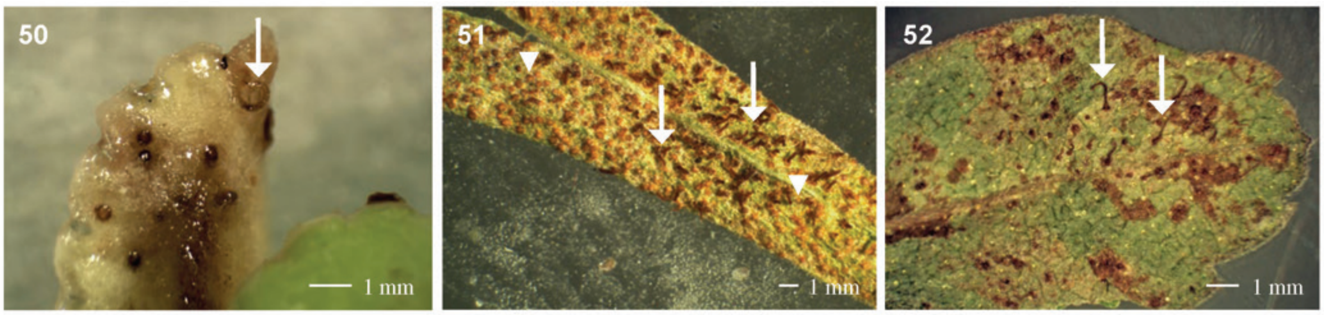


Figure 50—Telia of *C. flaccidum* on *Saxifraga hostii*.
Figure 51—Uredinia and telia of *C. flaccidum* on *Castilleja miniata*.
Figure 52—Telia of *C. flaccidum* on *Myrica gale*.