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Genetic Resistance to Currant Borer in *Ribes* Cultivars

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Abstract

The larvae of the currant borer (*Synanthedon tipuliformis* Clerck), a clearwing moth, are pests of cultivated black, red, and white currants (*Ribes* L.) throughout the world. While broad-spectrum insecticides are the standard control, more environmentally friendly techniques, such as mating disruption using synthetic pheromones, can be successful. Genetic resistance is not extensively reported or employed as a pest control strategy. We screened 150 diverse black (*Ribes* subgenus: Ribes section: Botrycarpum), red and white currants (*Ribes* subgenus: Ribes section: Ribes) at the U. S. Department of Agriculture, Agricultural Research Service, National Clonal Germplasm Repository-Corvallis (NCGR), for natural infestation by currant borer. Dependent on stem availability 130 dormant canes (about 20 cm) were collected. Canes were cut transversely, and dissected longitudinally. In highly infested black currant cultivars, such as *R. nigrum* L. 'Silvergeters Zwarte,' 2 or 3 larvae were observed within one cane. The *R. nigrum* 'Black Naples' derivatives, 'Saunders' and 'Kerry', had low larval counts, although 'Neosypaushayasya' was highly infested. Some black currant cultivars from Northern Sweden, Russia, and England had low counts. Cane borer larvae were not observed in any of the pink or white flowering currants, *Ribes sanguineum* Pursh or in golden currants, *R. aureum* var. *villosa* cvs. Crandall, Idaho or Gwens. Red currant hybrid cultivars with a complex pedigree containing *R. rubrum* with *R. multiflorum* Kit. ex Schult. cvs. Detvan, Mulka, Redstart, Rolan, Rosetta, Rondom, and Rovada, had low larval counts, although others of similar background, such as 'Blanka', were highly infested. The infestation frequency of the samples described a negative exponential function rather than a normal distribution.

Introduction

The currant borer is a serious pest of black and red currants in Europe, Asia, New Zealand, and Australia. The insect was first recorded in North America after 1850 (6) and has naturalized throughout the continent since then (3). Currants are a minor crop in the United States and commercial production is located in the Pacific Northwest.

In Washington, one to four applications of a broad-spectrum insecticide, such as fenpropathin, is recommended during the adult flight period (3), although control can be poor due to the short-term effect of the spray and the imprecise knowledge of the time of adult emergence. Biological control using parasitic nematodes (5) and synthetic pheromones for mating disruption (3) can provide control when infestation levels are less than 0.6 larvae per cane (James, per. comm.). Mating disruption pheromones have not yet been registered for commercial use in the United States.

Genetic resistance to the currant cane borer is not extensively reported or employed as a pest control strategy. Cone (2) observed different levels of borer infestation in two red currants, finding that *R. vulgare* 'Wilder' had a lower infestation level than did 'Red Lake', although the main thrust of his report encouraged chemical control. Cone attributed the different infestation levels of the two cultivars to plant habit and wood hardness. Agafonova (1) observed mid-level resistance in *R. nigrum* cv. Nochka and Naryadnaya (pedigree = 'Boskoop Giant' x 'Altai Giant')

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although most genotypes observed, including 'Golubka,' 'Primorsky Champion,' 'Neosypaushayasya,' 'Doch siberyachki,' 'Chernaya Lisavenko,' 'Surprise,' and 'Sladkaya' were susceptible. 'Minskaya' and 'Perspektivnaya' were highly susceptible. Jermyn (4) reported differential levels of infestation in New Zealand black currant cultivars and suggested that currant borer females could be differentially attracted or repelled by volatile 'fingerprints' which may differ among the cultivars. These reports imply differential genetic resistance to cane borers in *Ribes*.

During the past several years we have observed differential infestation of cane borers in cultivated *Ribes* as evidenced by the presence of cane borer larvae in some dormant stems and the lodging of canes in some cultivars during the summer.

The objective of our research was to screen diverse cultivars of black, red, and white currants for the presence of cane borer and to document the relative incidence of larvae in a cane after natural infestation. We wished to determine if the infestation level differed by genotype, location within the field, or age of the wood. We also wished to determine if genetically similar cultivars tended to have similar infestation levels.

Materials and Methods

The NCGR field *Ribes* collection was established in Corvallis, Oregon, in 1994. Broad-spectrum chemical insecticides have not been applied to this field. In February and early March 2003, 130 dormant canes (65 from each two plants) were collected from each of 120 cultivars. Of the 65 canes that were collected from each plant, 25 were from first-year, 25 from second year, and 10 from third-year or older wood. Canes were cut transversely every 0.5 cm, and dissected longitudinally when needed. The number of larvae per cane was recorded.

Results and Discussion

Genotype

The maximum cane borer infestation level of the NCGR-Corvallis field collection, 0.54 larvae/cane in *R. nigrum* cv. Silvergieters Zwarte (Table 1), was less than that reported by Jermyn (4) in New Zealand on commercial black currants, where 0.59 to 0.76 larvae/cane was observed. 'Blackdown' was the most highly infested black currant recorded by Jermyn, although, in our study, this cultivar was at a mid-level of infestation relative to other genotypes. In our study, in highly infested black currant cultivars, such as 'Silvergeters Zwarte' and 'Lissil', two or three larvae were often observed within one cane.

In red currant studies, Cone (2) reported from 0.4 to1.4 larvae/cane during three years in Prosser, Washington. Each year, infestation of *R. rubrum* 'Red Lake' was about half that of 'Wilder'. This concurred with our findings (Table 2) where 'Red Lake' had 0.03 larvae/cane while 'Wilder' had 0.06. Our study had less than one tenth of the total larval counts as the Prosser study, but the 'Red Lake' to 'Wilder' infestation ratio was consistently about 1:2.

Two of the cultivars that Agafonova (1) reported as susceptible, 'Neosypaus-hayasya' and 'Doch siberyachki', were also susceptible in our study (Table 1). Agafonova reported only relative resistance in the black currants that she studied but did not mention the number of larvae per cane. Relative levels of infestation that we observed on specific genotypes were consistent with these other reports although our total infestation tended to be lower than that reported in these other studies.

We did not observe any cane borers in the pink or white flowering currants, *R. sanguineum* cvs. King Edward VII, Elk River, Pokey's Pink, Claremont, Idaho, Hanneman's White, or White Icicle (Table 2). The causes of the observed resistance or apparent immunity are uncertain. The leaf morphology, high density of glandular hairs, strength of the wood, or pungent aroma of this species differ from other *Ribes* and may repel cane borers.

We compared the total number of larvae for the different ages of wood that were sampled. 14 % (250 of 1744 total) of the larvae occurred in first-year wood, 52% (907 of 1744) on second-year, and 34% (587 of 1744) on third year or older wood.

Table 1. Natural cane borer infestation level, larvae per cane, for black-fruited currants, (*R. nigrum* unless otherwise noted, *R. americanuum*^{z}, *R. aureum*^{y}, *R. sanguineum*^{x}) at the National Clonal Germplasm Repository, Corvallis, Oregon, during winter 2003.

No borers	**Resistant**	**Mid-level**	**Susceptible**	**Highly Susceptible**
0.00	0.01 to 0.1	0.11 to 0.20	0.21 to 0.30	0.31 to 0.55
Claremont^{X}	Alagan	Amos Black	Barhatnaya	August Reward
Crandall^{Y}	Baldwin	Belorusskaya sladkaya	Ben Connan	Hietala
Daniel's Black September^{X}	Ben Nevis	Ben Alder	Blacksmith	Jankisjarvi
Elk River^{X}	Boskoop Giant	Ben Lomond	Coronet	Silvergieters Zwarte
Hanneman's White^{X}	Brodtorp	Ben More	Davidson Eight	Viola
Idaho^{Y}	Champion	Ben Tirran	Erkiheikkii VII	
King Edward VII^{X}	Consort	Black Naples	Karlstein Longbunch	
Pokey's Pink^{X}	Coronation	Black Reward	Laxton's Nigger	
White Icicle^{X}	Cotswold Cross	Black Tony	Lissil	
Gwens^{Y}	Hatton Black	Blackdown	Mendip Cross	
	Hatton Giant	Bogatyr	Merton Cottage	
	Invigo	Climax	Neosypaushayasya	
	Invincible Giant Prolific	Crusader	Otello	
	Jet	Doch Siberyachki	Tinker	
	Kerry	French Black	Tough Champion	
	Kosmicheskaya	Gall^{Z}	Westwick Triumph	
	Laxton's Giant	Goliath		
	Laxton's Grape	Kantata		
	Magnus	Kantata		
	Malvern Cross	Kirovchanka		
	Minaj Shmyrev	Laxton's Standard		
	Mopsy	Lowes Auslese		
	Nikkala XI	Lunnaya		
	Noir de Bourgogne	Nasa		
	Nystawneznaja	Ojebyn		
	Ontario	Pino Debourksanof		
	Onyx	Polar		
	Pobeda (Victory)	Raven		
	Prince of Wales	Risager		
	Rain-in-the-face^{Z}	Schwarze Traube		
	Saunders	Seabrook Black		
	Sopiernik	Slitsa		
	Stella I	Tadd		
	StorKlas	Trinder's Long Buch		
	Strata	Wassil		
	Swedish Black	Willoughby		
	Tenah			
	Titania			
	Topsy			
	Tsema			
	Wellington XXX			
	Weswick Choice			

Parentage

Resistant black currants included selected clones from England ('Daniel's Black September', 'Onyx'), Sweden ('Nikkala II', 'StorKlas', 'Titania'), Canada ('Saunders', 'Mopsy', and 'Kerry'), and Russia ('Minaj Shmyrev') (Table 1). No cane borers were observed in *R. aureum* var. *villosum* cv. 'Crandall', Idaho, or Gwens. The 'Baldwin' derivatives ('Coronation,' 'Cotswold Cross,' 'Daniel's Black September,' 'Malvern Cross,' 'Wellington XXX,' and 'Westwick Choice') had lower levels of larvae than other black currants. While the resistant 'Kerry' 'Magnus', and 'Saunders' were derivatives of 'Naples', the cultivar itself, as well as two additional derivatives, 'Climax' and 'Neosypaushyasya', had high cane borer counts (Table 1). From the susceptible point of view, the cultivars originating from

Table 2. Natural cane borer infestation level, larvae per cane, for red currants, (*R. multiflorum* hybrid[Y], *R. rubrum*[X], *R. spicatum*[W] *R. vulgare*[V]) at the National Clonal Germplasm Repository, Corvallis, Oregon, during winter 2003.

No borers 0.00	Resistant 0.01 to 0.1	Mid-level 0.11 to 0.20	Susceptible 0.21 to 0.30	Highly Susceptible 0.31 to 0.55
Portal Ruby[X]	Chenonceau[V]	Blanka[Z]	Pomona[X]	Holland Longbunch[V]
Redstart[Z]	Cherry[V]	Cascade[V]	White Pearl[V]	Kromhout[V]
White Currant 1301[X]	Detvan[Z]	Champagne[V]		
	Fay[V]	Diploma[V]		
	Honeywood[V]	Gloire de Sablons[X]		
	Jonkheer van Tets[V]	Heros[V]		
	Karstein Red[V]	Holland Blanche[V]		
	Lack's Monster[V]	Houghton Castle[V]		
	Laxton's #1[V]	Minnesota 52[V]		
	London Market[X]	Minnesota 69[V]		
	Masons[V]	New York 68[X]		
	Minnesota 71[V]	Rosa Hollandische[W]		
	Moore's Ruby[Z]	Verriere Blanche[V]		
	Mulka[Z]	White Versailles[X]		
	New York 37[X]			
	New York 72[X]			
	Perfection[V]			
	Primus[Z]			
	Prince Albert[Y]			
	Raby Castle[X]			
	Red Lake[V]			
	Rolan[Z]			
	Rondom[Z]			
	Rubina[V]			
	Stanza[X]			
	Stephens[V]			
	Tatran[Z]			
	Versailles[X]			
	Viking[Y]			
	Weisse aus Juterbog[V]			
	White Grape[V]			
	White Imperial[X]			
	White Transparent[X]			
	Wilder[V]			

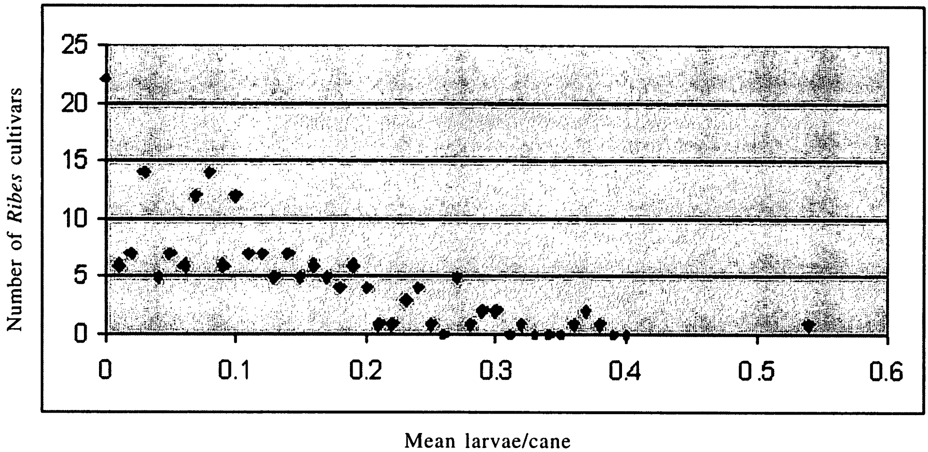
'Boskoop Giant' and 'Goliath' were susceptible to the larvae. Not only did 'Silvergieters Zwarte' (whose pedigree is 'Boskoop Giant' open pollinated) have very high larval infestation, but two of its offspring, 'Otelo' and 'Viola', did also.

In contrast, *R. multiflorum* appeared in the background of at least 10 of the red currant cultivars that had no or low cane borer counts (Table 2). The resistant red currant cultivars included 'Detvan', 'Moore's Ruby', 'Masons', 'Mulka', 'Primus', 'Redstart', 'Rolan', 'Rondom', 'Rosetta', and 'Rovada'. However, we note that 'Blanka', also a *R. multiflorum* derivative, was susceptible.

Genetic Resistance

We had expected that with the large diverse collection of cultivated currants at the NCGR-Corvallis, the frequency of distribution of resistance to cane borers would approach normal with the majority of cultivars being mid-level, trailing off to fewer equal amounts of cultivars being highly resistant or highly susceptible. However, the frequency for the resistance within the *Ribes* population (Fig. 1) behaved as a negative exponential function with 22 genotypes having high resistance, decreasing to a few genotypes with high susceptibility. We interpret this exponential distribution, because it was non-normal, to strongly indicate the differential oviposition of the female cane borers. Given this "choice test," the cane borer moths laid their eggs in specific *Ribes* genotypes and avoided "undesirable" ones so that the frequency of the larval presence was not a normal, random event. Further, we concur with Jermyn (4) that cane borer females, could be differentially attracted or repelled by volatile compounds from specific *Ribes* genotypes and species. Perhaps the morphological pubescence of *Ribes sanguineum* could also be a deterrent for the borer. Resistance to the cane borer is genetically influenced in *Ribes*.

Fig. 1. Frequency of currant cane borer larvae infestation in 150 *Ribes* currant cultivars sampled in February and March 2003, at the USDA, ARS, National Clonal Germplasm Repository in Corvallis, Oregon.



Conclusions

Because the distribution of cane borer larvae was observed to be non-normal in the diverse collection of *Ribes* cultivars examined in this study, we conclude that mechanisms for genetic resistance exist within the genus. Although we did not test this hypothesis directly, volatile compounds specific to *Ribes* genotypes may be the source of this resistance. Cane borer larvae infestation in *Ribes* also depends on the age of plants. Newly established plants had less infestation, and the highest levels occurred in second-year or older wood on older plants. Trends for heritability of susceptibility in *R. nigrum* cultivars were observed, while the tendency for resistance in derivatives of the red currant species *R. multiflora* was noted. Golden and red flowering currants were immune to infestation. From these results breeders could incorporate resistant genotypes and avoid susceptible ones in planning for the development of improved cultivars. Growers could select resistant genotypes for planting. Further studies will examine a broader selection of *Ribes* species for currant cane borer infestation.

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