FINAL REPORT

Weed Seed Predation by Carabid Beetles for Biological Control in Wild Blueberry Fields
(CAAP Project NS3560CO)

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BACKGROUND AND PROJECT RATIONALE

Wild blueberry (*Vaccinium angustifolium*) is an important horticultural crop in eastern Canada, with approximately $203 million in exports in 2011. Weeds are a major yield-limiting factor in blueberry fields. Growers rely heavily on herbicides but desire alternate weed control methods to avoid problems with pesticide residues on fruit, pesticide resistance, and environmental and non-target issues. Biological control is a useful pest management strategy whereby pest species are controlled with natural enemies, such as diseases, parasites, or predators.

The potential of seed-feeding beetles for biological control of weeds has been well recognized in several agroecosystems (Cromer et al. 1999; Gaines and Gratton 2010; Gallendt et al. 2005; Honek et al. 2006; White et al. 2007) but has been little studied in wild blueberries. However, in a recent study of Carabidae (ground beetles) in wild blueberry fields, we found a significant number of seed-eating species (Cutler et al. 2012). In addition, Boyd (unpublished data) has found that insects (beetles and crickets) will remove significant amounts of grass seeds from 'tray offerings' in blueberry fields.

The overall goal of the proposed research project was to test whether naturally occurring granivorous (seed eating) beetles have potential for biological control of certain weed species in wild blueberry fields. Because *Harpalus rufipes* was the most abundant beetle in NS blueberry fields, and because it is known to consume plant seeds, we focused most of our laboratory experiments on this species. Experiments examined weed seed consumption by this beetle, and its susceptibility to insecticides used in blueberry production. In addition, the field cricket *Gryllus pennsylvanicus* was found in different fields in Nova Scotia and was studied for its seed predation efficacy in the laboratory. Specific questions examined were:

1. **Do *H. rufipes* and *G. pennsylvanicus* consume sheep sorrel and hairy fescue seed in the laboratory?**
2. **Does seed consumption happen in the field and is this influenced by proximity to a forest edge?**
3. **Is *H. rufipes* susceptible to insecticides used in blueberry insect pest management?**

MATERIALS & METHODS

Laboratory Experiment

H. rufipes and *G. pennsylvanicus* were collected from blueberry fields using pitfall traps and returned to the laboratory. Beetles were fed cat food for 72 h and then starved for 92 h. Beetles were then placed in Petri plates with 25 sheep sorrel and 25 fescue seeds or 50 seeds of one type. There were 5 replicates of each treatment scenario. In late season, a number of *G. pennsylvanicus* were found in field and were tested for weed seed predation. Crickets were fed cat food for 48 h and then starved for 48 h, and crickets were then placed in Petri plates with 25 sheep sorrel and 25 fescue seeds or 50 seeds of one type. Treatments used in the beetle experiments were used for crickets. The number of seeds consumed per day was determined. Consumption in different treatments was compared by repeated measures analysis of variance.

Field Experiment

The experiment was done at a site containing a field in both the 'crop' and 'vegetative' phase of production (Fig 1). Seeds were offered on paper in the open (control), in cages that allowed insect access (caged), or cages that excluded insects (exclusion cage). A triplicate of cages was established along transects at 1, 15 or 55 m on each field, and there were 5 replicate transects per field. Seed consumption was compared using a general linear model.

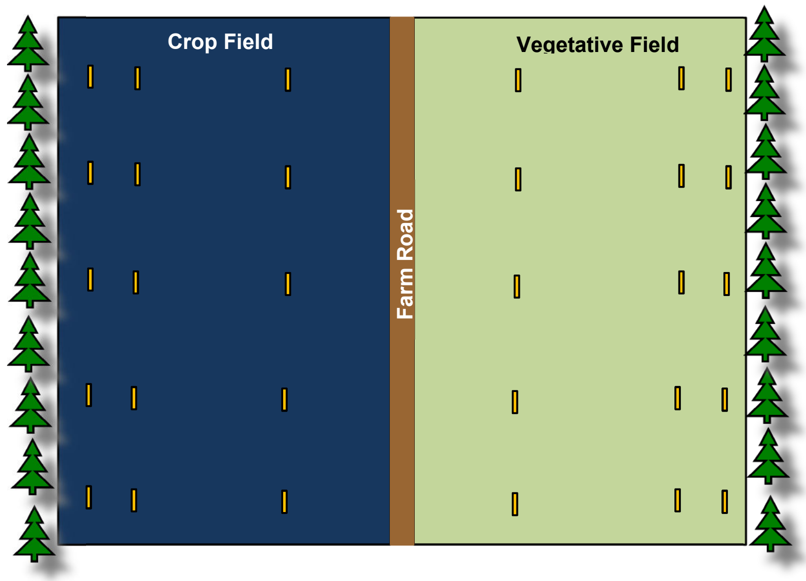

Fig 1. Layout of cages containing seeds (yellow rectangles) in wild blueberry field to determine consumption by seed-feeding beetles (2012).

Susceptibility to Insecticides

A Potter tower was used to spray beetles to test their susceptibility to different insecticides that are used in wild blueberry production during periods when sheep sorrel and hairy fescue set seed. Cohort of 3 beetles were sprayed with Movento, Assail or Imidan at different concentrations, ranging from 1/10 the field rate, to double (2X) the field rate. Survival was recorded after 48 h and there were three blocks in time. Data were analyzed by logistic regression.

RESULTS & DISCUSSION

In laboratory experiments, seed consumption by beetles varied among treatments, with more sheep sorrel seeds being consumed when offered alone than in other treatment ($F_{3,303}$ = 76.33; P < 0.0001) (Fig. 2). Seed consumption gradually decreased over time ($F_{3,303}$ = 51.68; P < 0.0001), although this varied among treatments (interaction: $F_{9,303}$ = 1.91; P < 0.051). The same trend was observed in seed consumption of sheep sorrel and fescue seeds in 2013 (Figs 3 and 4). The treatments were significantly different with consumption of sesame seeds (Control) being greater over sheep sorrel and fescue in choice (Treatment: $F_{2,\ 192}$ = 205.7; P <0.0001) and no choice (Treatment: $F_{3,\ 96}$ = 121.36; P <0.0001) experiments.

In the lab experiments with field crickets, more sheep sorrel seeds were consumed ($F_{1,29}$ = 33.32; $P < 0.0001$) when offered alone than in the other treatment ($F_{1,29}$ = 33.32; $P < 0.0001$) (Figs. 5 and 6). Seed consumption also varied over time ($F_{1,27}$ = 60.24 ; $P < 0.0001$), and among treatments (interaction: $F_{2,56}$ = 16.31; $P < 0.0001$).

In the field experiment, seed recovery differed by treatment in both the crop field ($F_{2,140}$ = 98.09; $P < 0.0001$) and vegetative field ($F_{2,126}$ = 135.77; $P < 0.0001$), with far fewer seeds being recovered in exclusion cages that were covered with a nylon stocking (Fig. 7). More seeds seemed to be consumed in the vegetative part of the field. There was no effect of distance from forest edge on the number of seeds recovered in each treatment (crop: $F_{16,337}$ = 0.81; P = 0.51; vegetative: $F_{16,337}$ = 1.01; P = 0.36), and the effect of distance did not differ among the treatments (crop: $F_{16,337}$ = 1.32; P = 0.26; vegetative: $F_{16,337}$ = 0.58; P = 0.56).

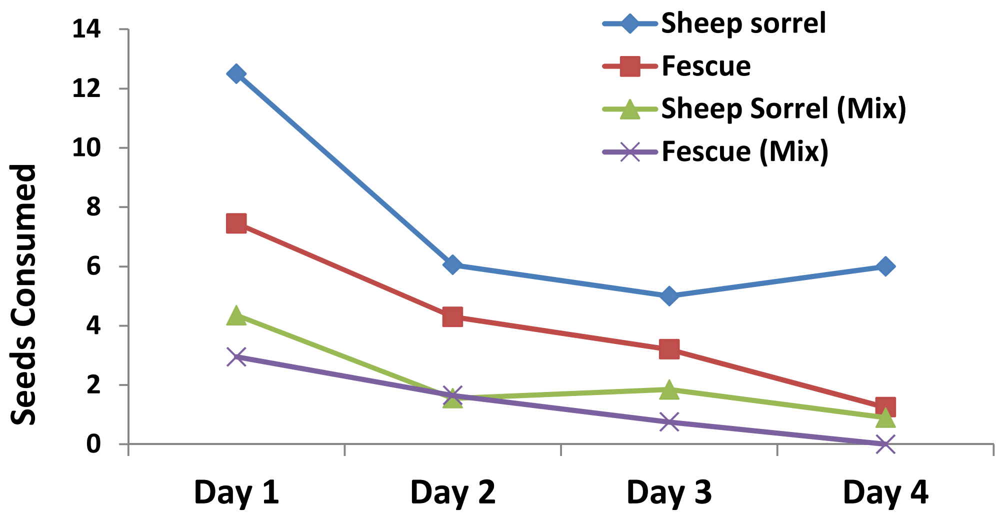

Fig. 2. Seed consumption of sheep sorrel and fescue seeds by *H. rufipes* in the laboratory (2012).

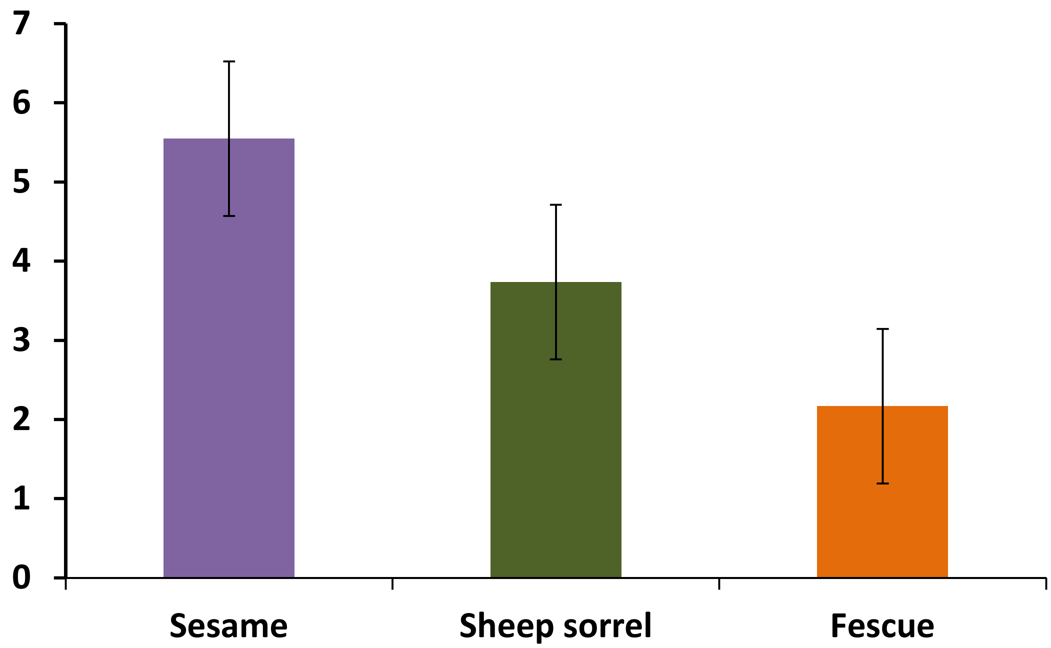

Fig. 3. Seed consumption of sesame, sheep sorrel and fescue seeds by *H. rufipes* in choice laboratory experiment (2013).

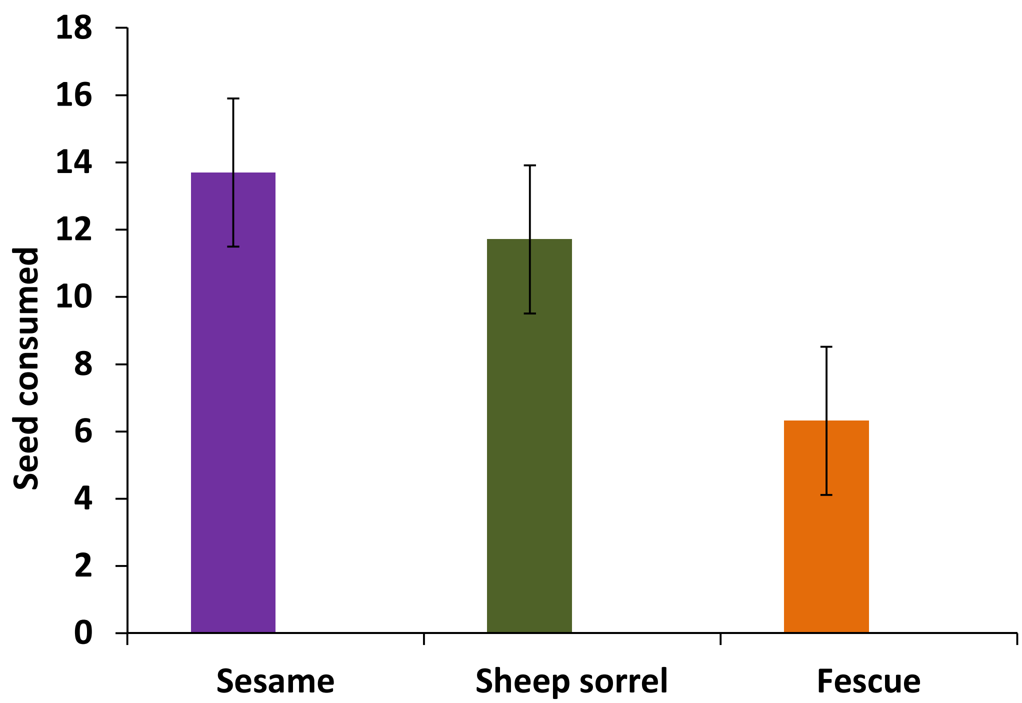

Fig. 4. Seed consumption of sesame, sheep sorrel and fescue seeds by *H. rufipes* in no-choice laboratory experiment (2013).

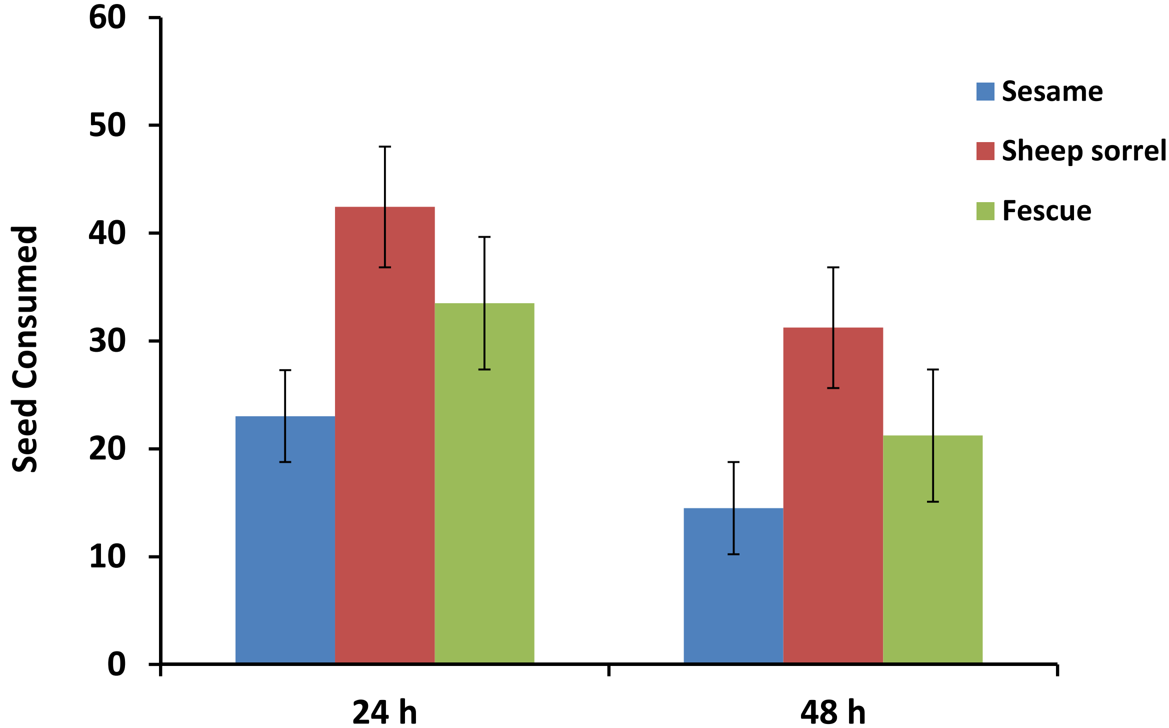

Fig. 5. Seed consumption of sesame, sheep sorrel and fescue seeds by *G. pennsylvanicus* in no-choice laboratory experiment (2013).

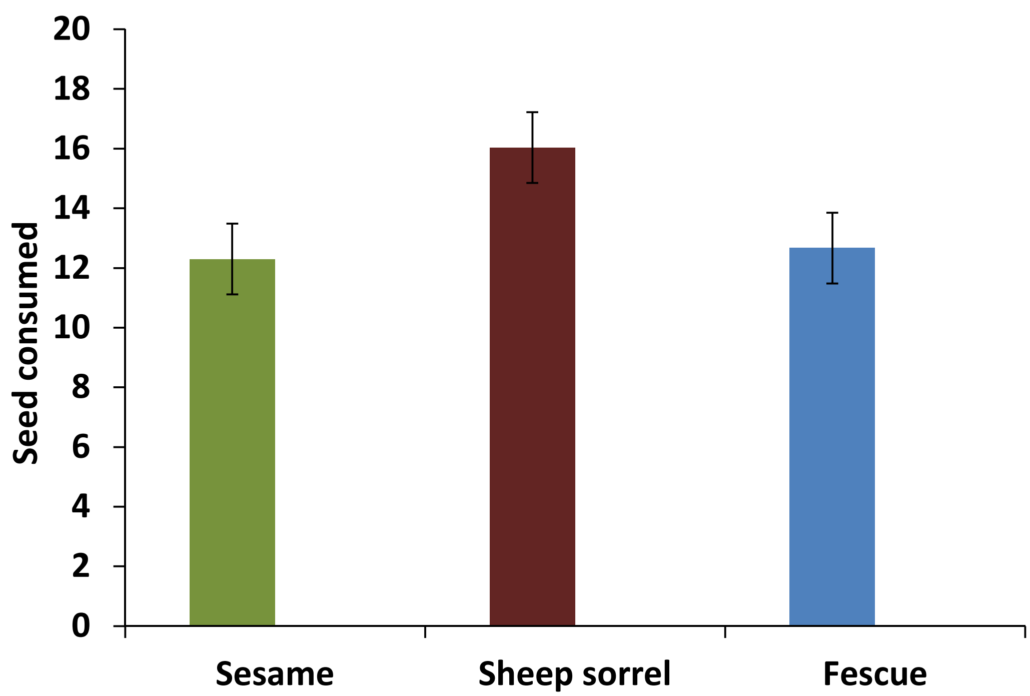

Fig. 6. Seed consumption of sesame, sheep sorrel and fescue seeds by *G. pennsylvanicus* in choice laboratory experiment (2013).

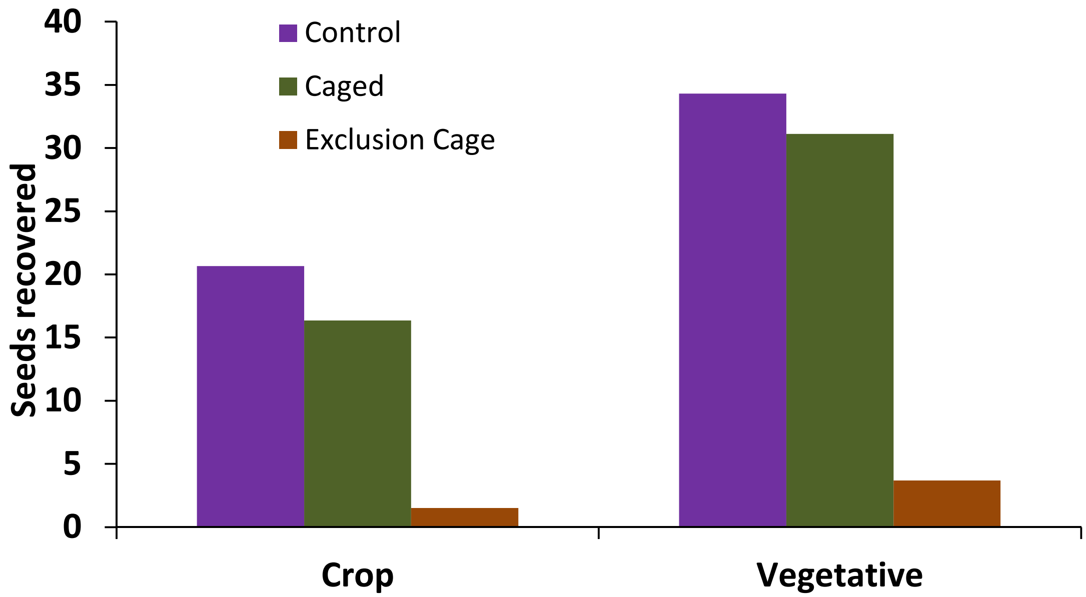

Fig 7. Field consumption of weed seeds by insects in wild blueberry fields, with or without exclusion cages.

In toxicology tests, beetles differed in the susceptibility to the different insecticide treatments (*P* = 0.012). Effects did not vary by block (*P* = 0.99), and there was no treatment*block interaction (*P* = 0.80). Beetle survival was only affected by exposure to topical sprays of Imidan at 2X the field rate (Fig. 8). Other treatments did not affect beetle survival.

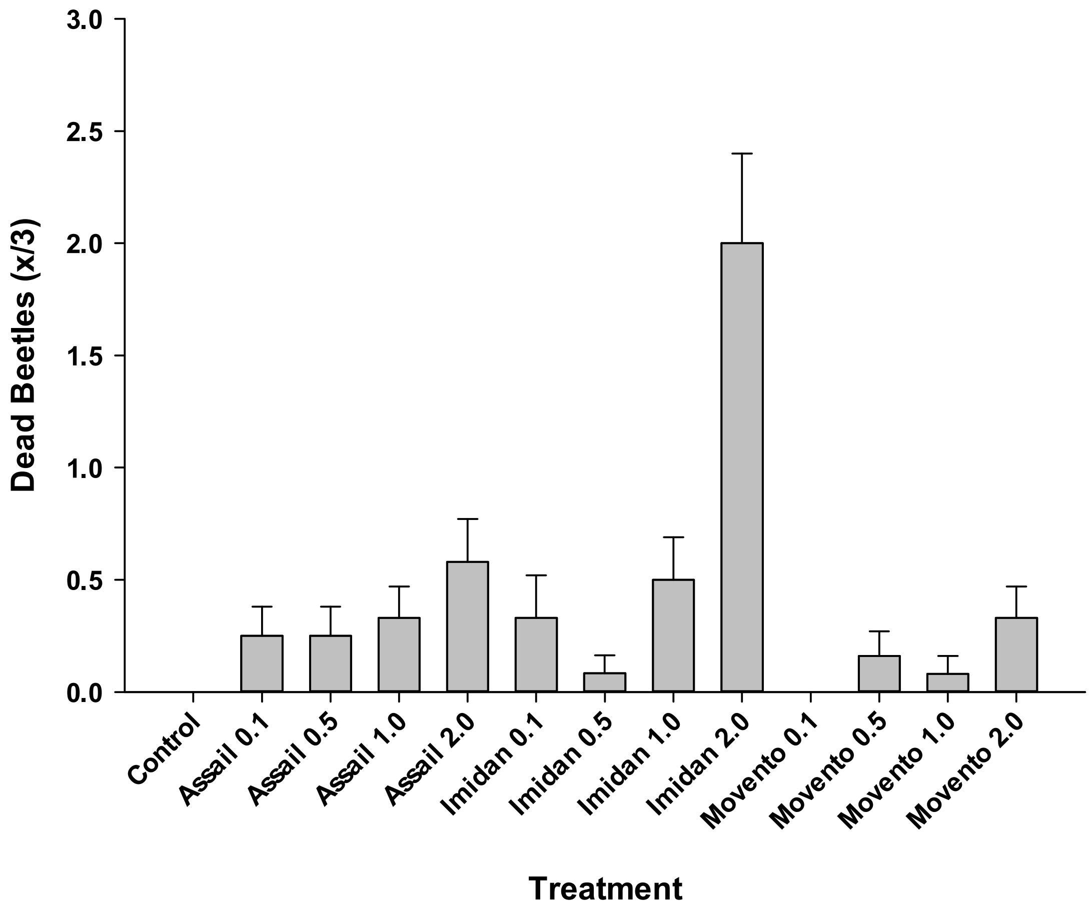

Fig 8. *H. rufipes* survival (+/- SEM) when topically treated with insecticides at various field rate concentrations (0.1-2.0 X field rate).

CONCLUSIONS

H. rufipes, a beetle that is very abundant in NS wild blueberry fields, can consume a significant number of sheep sorrel and hairy fescue seeds. *G. pennsylvanicus* was also found in large numbers in different fields in Nova Scotia and adults were recorded feeding on these weed seeds in laboratory experiments. Our field study showed that consumption also happens in the field, although other species of ground beetles and other insects likely consumed weed seeds in this experiment. How much seed-predation contributes to weed control in blueberry fields is unclear, but efforts should nonetheless be made to conserve and promote populations of these beneficial insects.

Experiments done with commonly used insecticides in wild blueberry show that several of these should be safe to *H. rufipes*. Direct topical exposure to insecticide sprays may not pose a hazard to beetles, but it is unknown if beetles are affects when feeding on seeds sprayed with these insecticides.

FINANCIAL REPORT
A report of all expenditures up to 30 Sept 2013 will be provided by Financial Services, Dalhousie University.

OTHER PROJECT NOTES
Presentations.
1. Chahil, G.S., G.C. Cutler. 2012. Consumption of weed seeds by Harpalus rufipes, a common beetle in lowbush blueberry in Atlantic Canada. Acadian Entomological Society Annual General Meeting, 15-17 August 2012, Fredericton, New Brunswick. (Oral presentation, Chahil)
2. Chahil, G.S., G.C. Cutler. 2012. Consumption of weed seeds by Harpalus rufipes, a common beetle in lowbush blueberry in Atlantic Canada. Entomological Society of Canada Annual General Meeting, 5-7 November 2012, Alberta (Oral presentation, Chahil)
3. Chahil, G.S., G.C. Cutler. 2012. Consumption of sheep sorrel and hairy fescue seeds by Harpalus rufipes in wild blueberry fields. WBPANS Annual General Meeting, 17 November 2012, Truro, NS (Poster presentation, Chahil).
4. Cutler, G.C., A. De Silva, G. Chahil, H. Crozier Blueberry insect hodgepodge: studies on insect chemical ecology, biocontrol and toxicology. WBPANS Annual General Meeting, 17 November 2012, Truro, NS (Oral presentation, Cutler)
5. Chahil, G.S., G.C. Cutler. 2013. Consumption of weed seeds by a common beetle and field cricket in lowbush blueberry in Atlantic Canada. Entomological Society of Canada Annual General Meeting, 20-23October 2013, Guelph (Oral presentation, Chahil)
6. Chahil, G.S., G.C. Cutler. 2013. Consumption of weed seeds by a common beetle and field cricket in lowbush blueberry in Atlantic Canada. WBPANS Annual General Meeting, 22 November 2012, Truro, NS (Poster presentation, Chahil).

Awards (Chahil)
1. Graduate Entrance Scholarship, Faculty of Agriculture, Dalhousie University ($5000)
2. Ed Becker Award, Entomological Society of Canada ($500)
3. Gordon B. Kinsman scholarship, Faculty of Agriculture, Dalhousie University

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Gaines HR, Gratton C. 2010. Seed predation increases with ground beetle diversity in a Wisconsin (USA) potato agroecosystem. Agric Ecosyst Environ 137: 329-336.

Gallandt ER, Molloy T, Lynch RP, Drummond FA. 2005. Effect of cover-cropping systems on invertebrate seed predation. Weed Sci 53: 69-76.

Honek A, Saska P, Martinkova Z. 2006. Seasonal variation in seed predation by adult carabid beetles. Entomol Exper Appl 118: 157-162.

White SS, Renner KA, Menalled FD, Landis DA. 2007. Feeding preferences of weed seed predators and effect on weed emergence. Weed Sci 55: 606-612.