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Project title: Biological Control of Delia sp. in Cole Crops with Rove Beetles, *Aleochara* sp. (Part 1)

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Project Summary

The results of this study demonstrated that *Aleochara* sp. beetles were present in both organic and conventional cole crop fields, in southwestern British Columbia. 301 *Staphylinid* beetles were captured in pitfall traps over the course of 14 weeks from June to early September. Of these 59 have been tentatively identified as belonging to the genus *Aleochara*. The native population of *Aleochara* beetles does have some impact on the *D. radicum* population, as was demonstrated by parasitism of overwintering pupae. More rove beetles, in general, were trapped in the grass margins around fields than in tree/shrub margins or within the field.

Although this project was intended as a specific study of *Aleochara* sp. we also considered rove beetles in general. This seems reasonable given that rove beetles are known to be generalist predators, although *Aleochara bilineata* is the most studied for purposes of root maggot biological control. The other *Staphylinid* genera and species present in the fields studied most likely contribute to the predation of *D. radicum* eggs and young larvae. Some of the genera similar in size and lifecycle to *Aleochara* sp. may also parasitize *D. radicum* pupae.

In small scale field trials mulching around plants with grass-clippings was shown to increase the presence of native rove beetles within the field. Introductions of *A. bilineata* helped to reduce the number of cabbage maggots infesting plants, in small field cage experiments. Both these techniques will be explored on a larger scale to further assess their operational feasibility and cabbage maggot control potential.

Introduction

The consumer demand for organic produce is increasing. In order for growers to be able to meet this demand, effective non-chemical tools need to be available for pest management. In BC in particular there is an increase in the production of organic cole crops, hence an urgent need to develop organic integrated pest management (IPM) systems that emphasize biological, cultural and other non-chemical methods (for insect and disease management). Among the main insect pests for cole crop production in the Pacific Northwest are root maggots (*Delia radicum*), aphids, flea beetles, thrips, and several lepidopteran pests. The root maggots are especially harmful when cabbage seedlings are small and cannot sustain loss of root tissue.

The non-chemical tools available for *Delia* management include biological control with nematodes, cultural control via timing plantings to avoid peaks in cabbage maggot populations, and physical control by covering seed beds with Remay® row covers. Timing for plantings and nematode applications is based on monitoring the population of *D. radicum* with yellow sticky traps. Both physical (row covers) and biological (nematodes) controls are very expensive to use once seedlings have been planted out in the field. Given the limited number of non-chemical tools currently available for organic cole crop production it is important to explore other options.

One such possibility is the rove beetle *Aleochara bilineata*. This species is both a predator of the *D. radicum* eggs and parasite of the pupae (Klimaszewski 1984) (Fig. 1).

Studies have indicated that native *Aleochara* species are an important component in suppressing *D. radicum* populations, especially in systems with reduced inseciticidal pressure (Finch 1989). Canadian studies have reported up to 90% parasitism of *D. radicum* by *A. bilineata* in fields where insecticides have not been used for extended periods of time (Turnock *et al.* 1995).

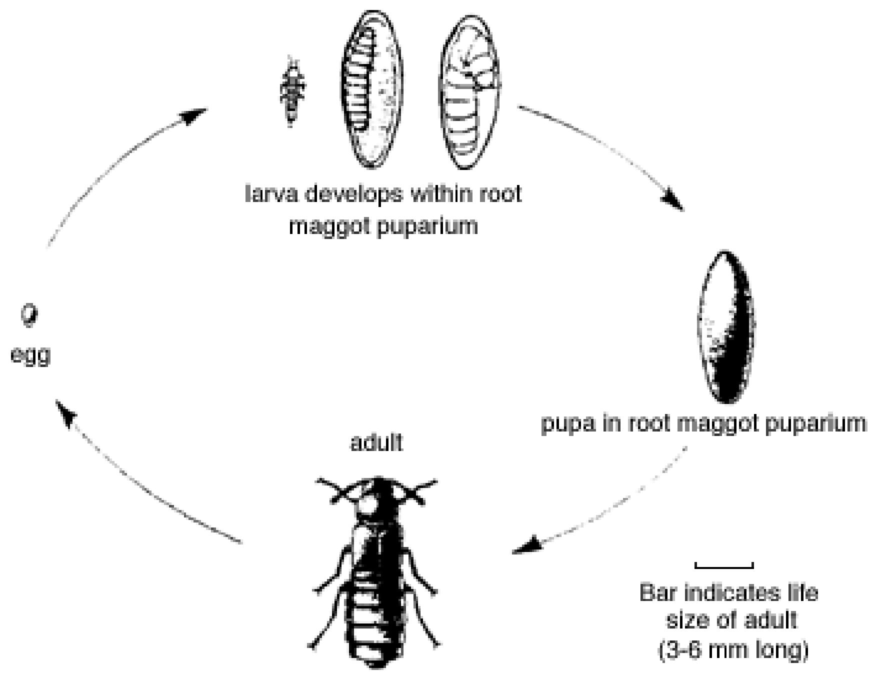

Figure 1. Lifecycle of *Aleochara bilineata*. Adult stages eat *D. radicum* eggs and larvae and pupa stages occur within the root maggot puparium. From Weeden 1997.

Levels of parasitism of *D. radicum* by native populations of *A. bilineata* have not been documented for southern British Columbia. As the activity of native *Aleochara* beetles is unpredictable (Turnock *et al.* 1995) the emphasis of recent studies has been to enhance the biocontrol potential of *A. bilineata* by either increasing habitat for native populations or introducing mass-reared individuals.

The conservation approach focuses primarily on vegetation management practices that increase habitat for generalist predators, such as *A. bilineata* but also other coleopterans and arthropods. These practices may include maintaining heterogeneity at field margins, in-field use of beetle banks, mulching or under sowing with cover crops (Kross and

Shaefer 1998, Hellqvist 1996). Providing habitat may improve effectiveness not only of native populations, but also introduced beetles.

Introduction of mass-reared *A. bilineata* for early season control of *D. radicum* is also being examined. The first generation of *A. bilineata* does not coincide with the laying of first generation *D. radicum* eggs in the early spring and it is this generation that causes the most serious damage. Predation of eggs and larvae by introduced *A. bilineata* may reduce levels of damage at this time. Past research has shown that biological control with *A. bilineata* may not be cost effective given the release rates needed (20,000 to 60,000 per ha) and the labour needed to produce beetles (10hr per 20, 000). However, current research on infochemicals (Royer and Boivin) and *Aleochara* behaviour (Royer et al. 1998, 1999) suggest that there may be strategies that can improve efficacy of introduced beetles. In addition, higher and more expensive release rates would be needed for conventional cropping systems where beetles are used in an innundative manner (e.g. biopesticide). Innoculative releases (lower release rate and less frequent) may be more appropriate in organic systems where a number of other tactics are being employed, such as habitat conservation and reduced insecticide pressure.

Documenting the level of activity of native *A. bilineata* would be beneficial to the organic community at large, especially in southern British Columbia and the Pacific North-West. Rove beetles are generalist predators and their conservation through field management practices would provide enhanced biological control of other pests for other crops. The potential to use mass-reared *A. bilineata* for biological control of *Delia* pests in the early spring will increase the non-chemical options available to organic growers.

Objectives

The initial set of objectives stated in the proposal submitted in January, 2000 were as follows:

1. To determine the species composition, phenology and levels of parasitism activity of native rove beetles (*Aleochara* sp.) in southern British Columbia.
2. To determine vegetative and field management techniques (e.g. beetle banks, grass margins and hedgerows) that enhance native rove beetle populations.
3. To compare the efficacy of native *Aleochara* populations versus innoculative releases of mass-reared *A. bilineata* in controlling *D. radicum* in the early season.

Due to the late start of the project, (end of May instead of early March) we were unable to carry the second and third objectives out as originally intended. We were able to compare rove beetle activity in different types of field margins in conjunction with trapping efforts for the first objective. We conducted preliminary trials to test the impact of introductions of beetles versus native beetles and the effect of mulch treatments. The focus of this report is primarily on the first objective: a survey of native rove beetles with particular attention to the genus *Aleochara*, and a summary of the results of the two preliminary trials.

Materials and Methods

The research was carried out in four organic fields, in Ladner, BC and one conventional field, in Abbotsford, BC (Table 1). All fields were under normal crop management practices. In fields 1 and 4 a portion of the fields were left specifically for research purposes and were not cultivate as frequently as the rest of the field.

Table 1. Summary of fields used for collecting rove beetles with pit fall traps, 2000

Field	Location	Crop 2000	Crop 1999	Other Notes
1 (organic)	Ladner	broccoli	setaside	
2 (organic)	Ladner	seed bed (cauliflower)	setaside	sandy soil
3 (organic)	Ladner	potatoes	broccoli	
4 (organic)	Ladner	cauliflower	cauliflower	
5 (conventional)	Abbotsford	broccoli	broccoli	no crop rotation 7 years

Objective 1- Documenting existing level of activity

Pitfall trap survey for *Staphylinid* beetles

Five pitfall traps were placed in each of the five fields between the end of May and beginning of June 2000. A trap consisted of a 500ml Mason jar and 20 cm^2 wooden cover (Fig. 2). The traps were placed in fields in locations representative of the different habitats and vegetation patterns in each field. These include grass versus shrub or tree margins and in-field (crop) locations. Traps were buried up to the rim of the Mason jar, i.e. jars were flush with the ground. Each trap was filled with 50 ml of soapy water. Traps were checked on a weekly basis and the contents removed. Each week the mason jars were rinsed and re-filled with a fresh soap and water solution. Contents from traps were labeled and returned to the lab where they were sorted and categorized. All *Staphylinid* beetles were measured and saved in a 70% alcohol solution for later identification.

Covered pitfall traps

The capture efficiency of covered or fenced pitfall traps was compared with that of the standard pitfall trap (see above). Three covered traps per field were placed randomly in fields 1, 3, and 4 on June 15. The pitfall part of the trap was similar to those described above, i.e. 500 ml mason jar filled with 50ml of soapy water and buried up to the rim. Instead of a wooden cover the pitfall was enclosed by a 17 cm high X 30 cm diameter inverted plastic bucket. The bottom of the bucket was cut out and covered with a fine mesh. Buckets were inverted over the pitfall and were pressed firmly into the soil, such that the rim was at least 2 cm below the soil surface (Fig. 3). The total soil area encompassed by the inverted bucket covers was 0.071 m^2.

Traps were checked weekly, in a similar manner as standard traps. Unlike the standard traps, covered traps were moved each week after the contents of the pitfall was collected. Covered traps were moved about 2 to 5 meters from the previous weeks location. New holes for pitfalls were dug and bucket covers were placed as described above. Data from the covered and standard (uncovered) pitfall traps was compared for fields 1, 3, and 4.

<u>Parasitism of *D. radicum* pupae</u>
In the late fall, 10-20 plants from each of Fields 1, 4 and 5 were pulled out manually and the number of *D. radicum* pupae in the surrounding soil (6 cm diameter and 10-15 cm depth) were uncovered using a trowel, counted and collected in-situ. As well, 10 plants from a second conventional field ("Field 6') were also assessed for cabbage maggot pupae. Pupae were saved and held at 21^{o}C to allow adults to emerge.

Objective 2- Effect of habitat
The effect of habitat on *Aleochara* and *Staphylinid* activity was examined in two ways. Firstly, pitfall traps were placed in a variety of habitats in each of the five fields thus providing an opportunity to compare trap catches in each field based on the vegetation surrounding each trap (see Objective 1 Methods). Table 2 summarizes the number of traps in each habitat type for each of the five fields used for the trapping survey. Secondly, a small study involving manipulation of habitat via mulching was also undertaken. The methodology for the mulching experiment is summarized below.

Table 2. Location and number of pitfall traps in different habitats around fields used to monitor rove beetle activity

Field	Grass margin	Tree/shrub margin	In-field (crop)
1	2	0	3
2	1	1	3
3	2	2	1
4	3	0	2
5	2	3	0

<u>Mulching</u>
Preliminary trials of the mulching experiment were conducted in May and June 2000. Mulching experiments were carried out in Field 1. Organic grass mulch was obtained from an organic field used for pasture (Soeten Farms, Matsqui, BC). Mulch was applied in a 5 cm deep layer around 30 broccoli plants (3 rows with 10 plants each). Each group of 30 plants represented one plot. A total of 10 plots were used, alternating 5 control plots and 5 mulch plots. All 10 plots were in the same 3 rows and were at least 15 meters apart. Plants were on average 18cm high when mulch treatments were applied. Prior to mulch application two plants per plot were also checked for cabbage maggots, by manually pulling up plants and checking roots for *D. radicum* larvae. Cabbage maggots were not present in any of the study plots, however maggots were present in other parts of the field.

Five weeks later, in early July, soil samples were taken from 2 of the 5 mulched plots and 2 of the 5 control plots. Plots to be sampled were randomly selected. For each plot sampled, soil surrounding the roots of 3 plants in the middle of plots was removed with a hand trowel, after plants were pulled out. The amount of soil removed covered an area of

6cm diameter and 10 cm deep around each plant and was approximately 500 cc in volume. Thus for each of the four plots sampled 1500 cc of soil was collected. Soil was visually examined and the number of *D. radicum* pupae and adults was counted.

On July 13, one pitfall trap was placed in the center of three of the plots treated with mulch. These traps were handled in a similar manner as described in Objective 1 above. Data from pitfall traps in mulched plots was compared with pitfall trap data from the three in-field (crop) traps already in Field 1 (unmulched).

Objective 3- Impact of Introductions

A preliminary trial of *A. bilineata* introductions was conducted at the end of May. This trial was conducted in Fields 1 and 2. A small colony of *Aleochara bilineata* adults (25) were shipped from Agriculture Canada (Ste. Jean, PQ). Adults were fed before being shipped and were transported in a moist sand medium. Upon arrival at ESC, beetles were held at 20°C for 3 days before being used in Field 2 and 1 week before being used in Field 1.

The impact of beetle introductions was assessed in small cages, placed randomly in the crop of Fields 1 and 2. Cages consisted of a plastic bucket (30 cm diameter X 50 cm height) that was screened around sides and at the top. Cages were inverted over the plant(s) thus enclosing the plant(s) and beetles (Fig. 4). In Field 1, one plant was enclosed under each cage and in Field 2 approximately 10-14 plants (seedlings) were enclosed under each cage.

The study consisted of three treatments:

1. Beetles: approximately 3 to 4 beetles were released per cage/plot.
2. A cage only treatment was also included to control for any effects of the cages on plant growth.
3. A control treatment (no cage or beetles) was marked with flagging tape and consisted of a similar number of plants as the caged treatments: 14 plants per treatment in Field 2 and 1 plant per treatment in Field 1.

In each of these three treatments approximately 30 *D. radicum* eggs were sprinkled around the base of plants. Each treatment was replicated twice in each field. The number of adult *D. radicum* available limited the level of replication for this study.

The impact of treatments was assessed five weeks later, in early July. Plants from each plot/cage were removed and roots excised from below the first leaf node. Roots were washed in a water bath for 10 minutes then under running water for 2 minutes to remove soil and other debris. Fresh weights were recorded. Roots were dried in a drying oven (38°C) for two weeks and dry weights were then recorded.

A 500ml soil sample was also taken from each plot at the time roots were collected and the number of *D. radicum* pupae per soil sample was assessed. Soil samples were removed manually with a trowel and visually examined for 15 minutes. Cabbage maggot pupae were removed as they were encountered.

Results and Discussion

1. Documenting existing levels of activity

A total of 267 *Staphylinid* beetles were caught in the 25 standard pitfall traps from May 24 to Sept 7. An additional 18 were caught in the 9 covered pitfall traps and 17 were caught in the three pitfalls placed in mulched plots. Of these 302 *Staphylinids*, 65 have been tentatively identified as belonging to the genus *Aleochara*, or 21.6% of the captured individuals. The data for pitfall trap catches is summarized in Table 3. Unfenced pitfall traps have been shown to be relatively weak basis for making density estimates on arthropods such as the *Staphylinids* (Holland and Smith 1999). These authors recommend using covered or fenced pitfall traps as a more reliable method of obtaining data about arthropod populations.

In this study there was no significant difference between the numbers of beetles caught per covered versus uncovered or standard pitfall trap (Chi-Square Approximation=2.4071, DF=1, p=0.12)(Fig. 5), however this may have been a consequence of the small area enclosed by covered traps ($0.071m^2$). Covered traps used in other studies have ranged in size from 0.25-1m2 (Holland and Smith 1997). Although the pitfall trap data collected in this study cannot be used to make generalizations about the abundance of *Aleochara* sp. versus other *Staphylinids*, this data does document that beetles from this genus (and possibly closely related genera) are part of the complex of Staphylinids in southwestern BC. Also the data demonstrates that the *Aleochara* beetles are present in fields where they may contribute to the natural control of the pest *D. radicum* either by predation of eggs and young larvae or parasitism of pupae.

The peak in rove beetle, including *Aleochara* sp, catches occurred between June 15 to July 6 (Fig. 6). This first peak corresponded to the second peak in *D. radicum* population. This follows the population pattern for these two species reported by others (Whistlecraft *et al.* 1985, Finch 1989). The rove peak represents the overwintering generation of beetles and occurred approximately three weeks earlier than has been previously reported (Weeden 1997). A second smaller peak in rove beetle catches occurred later in the summer, during mid-August. This second peak may have been larger or lasted into September, however trapping was completed at the end of August. Again the timing of the second peak has been reported to be later in the literature (Weeden 1997). A trapping schedule that starts earlier (end of March) and lasts later (end of September) is recommended for 2001.

Figure 6 represents the rove beetle catch for all traps pooled together. The number of beetles and cabbage maggots caught in traps varied considerably between individual fields (Fig. 7 a and b, Table 3). The variability of beetle numbers in the different fields is probably related to a number of factors. For example in Field 4, a large chicken manure pile was located at the end of the field where our study was conducted. Most rove beetles are associated with decaying organic matter, including compost piles (Weeden 1997). It is interesting that the only conventional field, Field 5, had the second highest capture of rove beetles. This field is, however, unusual in that pesticides for cabbage maggot or any other insect have not been applied and the field has been in 7 years of continuous broccoli culture, without any economic insect damage (M. Sweeney pers. com).

Table 3. Summary of rove beetle catches for summer 2000, in southwestern BC

Date collected	Field 1	Field 2	Field 3	Field 4	Field 5
June 1	0	0	7	not out	not out
June 7	5	4	7	not out	not out
June 15	1	2	1	16	20
June 22	3	1	0	14	missed
June 29	1	52	4	7	26
July 7	5	9	10	2	7
July 13	3	0	1	4	1
July 20	0	0	9	7	2
July 27	0	1	0	5	0
Aug 3	0	0	0	0	1
Aug 10	4	0	6	1	0
Aug 17	0	0	0	4	8
Aug 24	1	1	1	1	0
Aug 31	0	0	0	2	0
Sept 7	0	0	0	0	0
FIELD TOTALS	23	70	46	63	65

Parasitism of *D. radicum* pupae was also assessed. Eighty-two pupae were collected in November 2000 (Table 4). The majority of pupae were collected in the organic broccoli field (#1). The fewest pupae were found in the conventional fields (#5 and 6). Of these Field 6 was treated with insecticide for maggot control during the growing season. However, in Field 5 no insecticides were applied in 2000, or in the previous seven growing seasons. This field appears to be quite unusual and it is recommended that it be monitored more thoroughly in 2001, including sticky trapping for adult *D. radicum* activity and sampling transplants for cabbage maggots.

Emergence of adults occurred in 14 of the 82 pupae by December 15, 2000. Two *Aleochara* adults were observed among the emerged adult stages from Field 4 pupae. This represents 15.79% parasitism of *D. radicum* pupae by *Aleochara* for field 4 and 3.66% parasitism for all the pupae collected. However, the majority of pupae have not had emergence of adult stages yet, thus it is premature to comment any further on the level of impact of native *Aleochara* on *D. radicum* populations. In other studies pupae are held at cold temperatures for approximately three to four months and then held at 21°C to monitor adult emergence (Turnock *et al.* 1995, Jonasson *et al.* 1995). The remaining pupae for this study have been placed at 5°C and will be removed in early March to confirm parasitism.

The hymenopteran parasitoids collected from Field 1, are most likely be related to *Trybliographa rapae* (Hymenoptera:Cynipidae). Parasitism of *D. radicum* pupae by cynipid wasps has been reported by other authors (Turnock et al. 1995, Langer 1996). Interestingly, there have been no studies of the biocontrol potential of these parasitoids.

For 2001, sticky traps should also be monitored for the presence of hymenopteran parasitoids and the identity of those recovered in 2000 will be confirmed.

Table 4. Assessment of *D. radicum* pupae for *Aleochara* parasitism

Field	# plants examined	# pupae	Emergence[1]	% parasitism[2] in field
1	20	59	5 wasps	8.47%
4	10	19	3 beetles, 7 *D. radicum* flies	15.79%
5	15	3	not yet	n/a
6	10	1	not yet	n/a

1. Emergence of adult stages as of Dec 15, 2000
2. Based on emergence of adults as of Dec 15, 2000

2. Effect of Habitat

Existing Habitat

Pitfall trap data was divided according to the main vegetation characteristics in the area around each trap. Three habitat categories were present in the five fields used for this study: grass margins (Fig. 8), tree and/or shrub margins (Fig. 9) and in-field (crop). Table 5 summarizes the trap catches for *Staphylinids* in the different habitats. Significantly more *Staphylinids* were found in grass margins as opposed to tree/shrub margins or in the field (Chi-Square Approximation=6.14 DF=2, p=0.0463). In 1996 a survey of margins, set asides and hedgerows found more *Staphylinids* in young hedgerows than in other types of habitats (Braybrooks 1996). The compositions of a young hedgerow (young trees and small shrubs) would include a lot of grasses and weeds. In this study the tree/shrub margins were very mature with older trees and large shrubs. *Aleochara* beetles were found primarily in traps placed along grass margins (27 out of 65) and traps placed within the crop (in-field) (27 out of 65). The large number of *Aleochara* beetles caught within the crop again supports other evidence that these beetles are having an impact on *D. radicum* populations, either as predators or parasitoids.

Table 5. Pit fall trap catches of *Staphylinid* beetles, in different habitats associated with agricultural fields.

Habitat Type	# Traps	Total Staphylinids Caught	Median[1] Beetles/trap	Upper and Lower Quantiles
Grass Margin	10	157	14	8.75-38.5
Tree/Shrub Margin	6	76	3.91	2.63-8.58
In field	9	38	5	5-13.67

1. Data not normally distributed

Manipulating Habitat

Half as many cabbage maggot pupae were found in soil samples taken from mulched versus unmulched plots (Table 6). As well, we found 2 rove beetles in the mulched plots and none in the unmulched plots. The pitfall trap collections in mulched plots also showed more rove beetle activity in these plots than compared to unmulched parts of the field (Fig. 10). These results provide promising evidence to justify further study of this conservation tactic. Mulching an entire field may not be feasible operationally, however mulching could be used effectively in seed beds or when combined with beetle releases in specific areas of fields, e.g. edges or every 10^{th} row. These results concur with previous evidence that shows an increase impact of natural enemies in agro-ecosystems with increased vegetative diversity (Thies and Tscharntke 1999).

Table 6. The effect of grass mulches on the number of *D. radicum* and Staphylinids in soil samples collected around roots of broccoli plants, five weeks after application of mulch treatments. Each entry represents the total number of pupae and beetles recovered from 1500 cc of soil from each plot.

Treatment	# *D. radicum* pupae	# Staphylinids
Mulched	4	0
Mulched	0	2
Unmulched (Control)	1	0
Unmulched (Control)	7	0

Impact of Introductions
Soil samples taken from treatments with beetles had lower numbers of *D. radicum* pupae than samples taken from treatments without beetles (Fig. 11). Visually as well, roots from control plots had more cabbage maggot feeding damage than roots from beetle treated plots. These observed differences in root appearances were not, however, confirmed by root weight data (Table 7). There were no significant (F=0.2006, df=2,9, p=0.8216) differences in the root dry:fresh weight ratios amongst the control, cage only and cage+beetles treatments. Crucifers are most susceptible to cabbage maggot damage when they are young and root tissue is minimal. Plants used for this study were perhaps old enough, i.e. had enough root tissue, that they did not sustain very much loss in terms of root tissue. This experiment should be repeated on a larger scale in 2001.

Conclusions

Native populations of *Aleochara* sp. are present and active in cole crop fields and have some impact on *D. radicum* populations. As the majority of pupae collected in the fall have not had adult emergence it is premature to comment on the level of control achieved via parasitism of *D. radicum* by native populations of *Aleochara* sp. Parasitism by *A. bilineata* appears to be at least in 15.78% in the one field (Field 4) in which parasitism activity has been documented so far. Our preliminary trials have demonstrated promising possibilities for mulching as a means of providing more infield habitat for native populations of rove beetles. Introductions of mass-reared *A. bilineata* were shown to be quite effective, on the small scale, at lowering the number of *D. radicum* infesting plant roots.

Table 7. The effect of *Aleochara bilineata* introductions on mean root dry: fresh weight. Plants in Field 1 were broccoli and plants in Field 2 were

Treatment	N*	Fresh weight	Dry Weight	dry:fresh
Field 1 control	2	20.2	4.43	0.22
Field 1 cage only	2	8.84	1.5	0.17
Field 1 cage+ beetles	2	13.3	2.13	0.16
Field 2 control	23	18.4	6.52	0.35
Field 2 cage only	24	15.85	6.07	0.38
Field 2 cage+ beetles	28	10.7	3.54	0.33

*N= the number of roots measured

Outreach

Outreach to growers and other researchers who work with growers will be made via oral presentations at the Lower Mainland Horticultural Improvement Associations grower short courses on Feb. 16, 2001. Copies of the final report have been forwarded to and an oral presentation is being arranged for the BC Association for Regenerative Agriculture (BCARA). A scientific note is being prepared for submission to either the Canadian Entomologist or the Journal of Economic Entomology.

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Figure 2. Standard pitfall trap cover.

Figure 3. Covering for the fenced or covered pitfall trap.

Figure 4. Bucket cages used for preliminary *Aleochara bilineata* release trials in Fields 1 and 2.

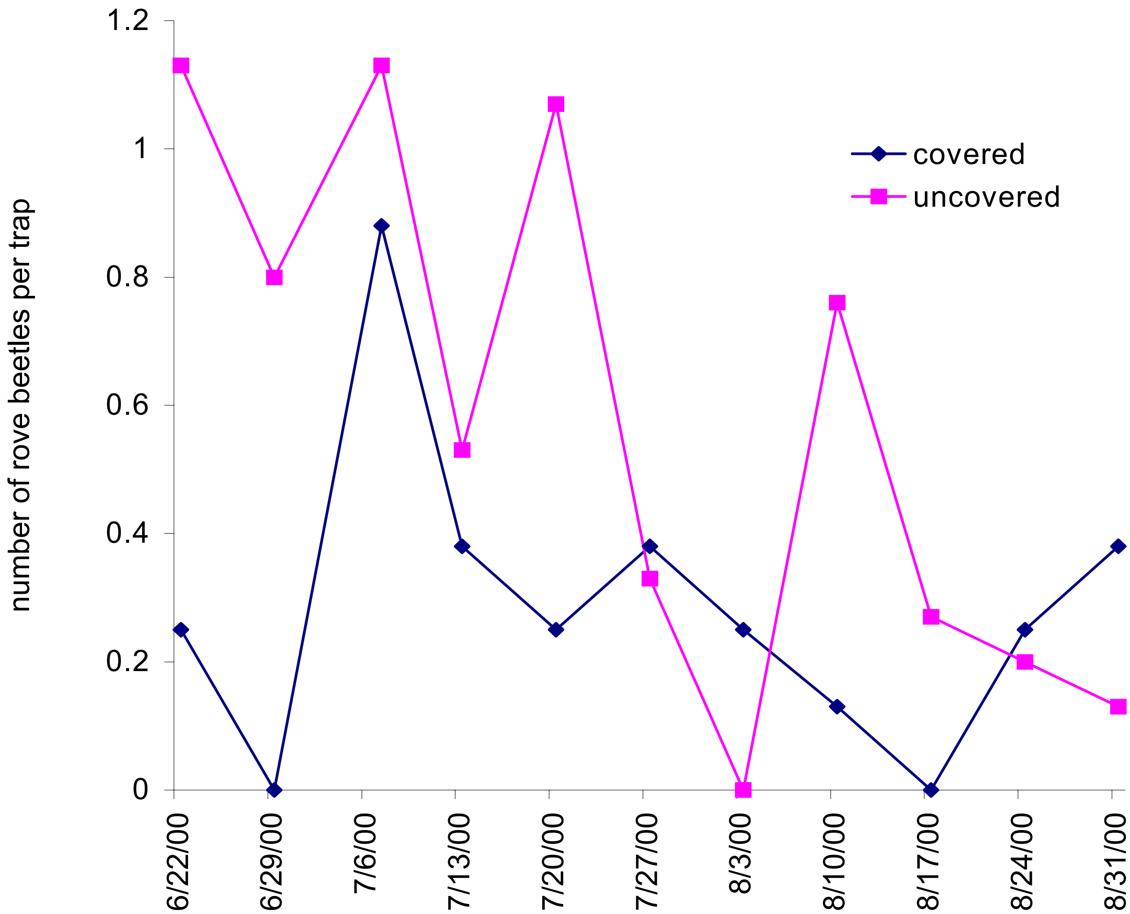

Figure 5. Comparison of rove beetle catches in covered vs. uncovered pitfall traps.

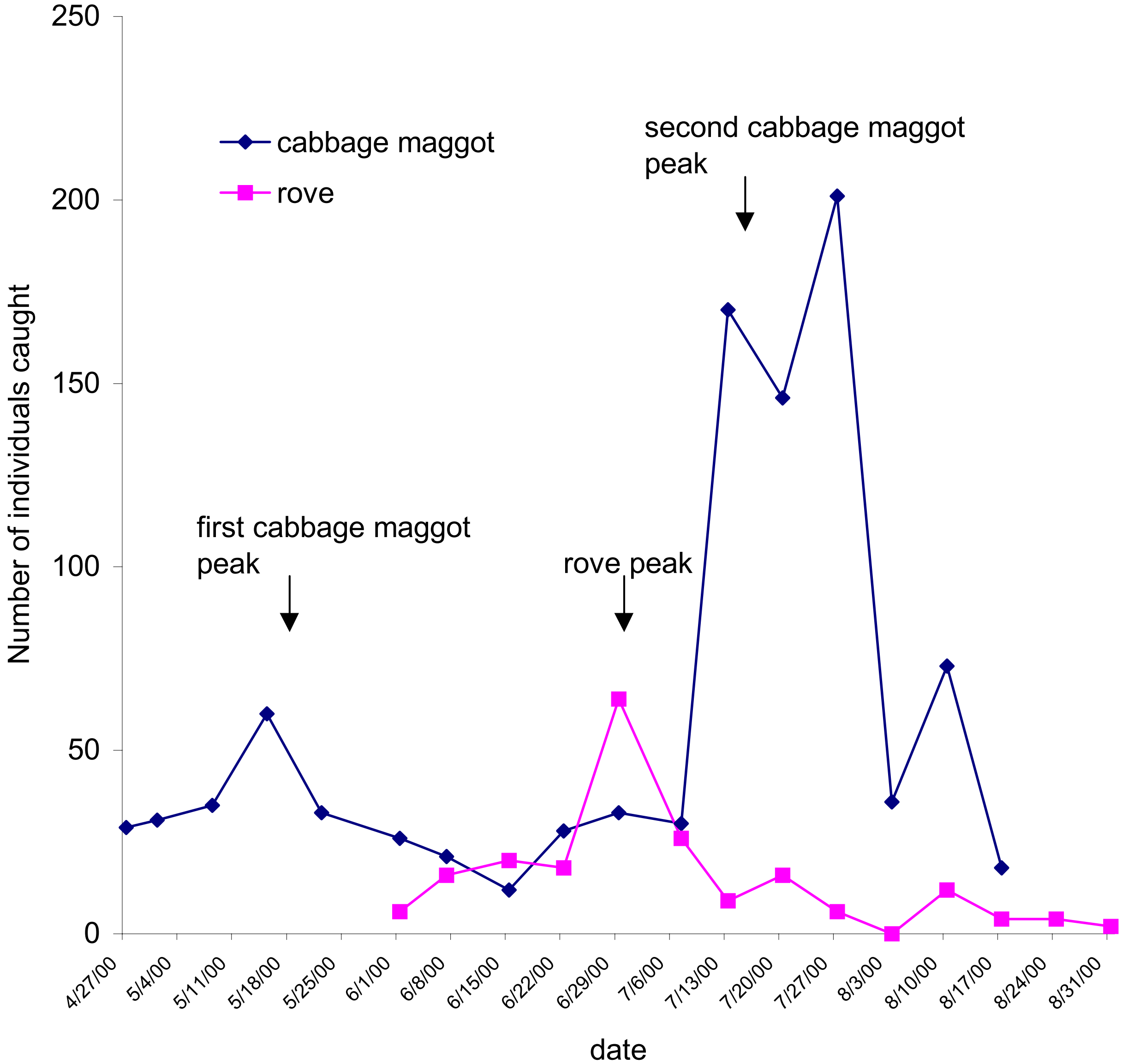

Figure 6. Rove beetle and cabbage maggot catches during summer 2000. Rove beetle catches represent the totals for 25 pitfall traps and cabbage maggot catches represent the totals for 6 yellow sticky traps

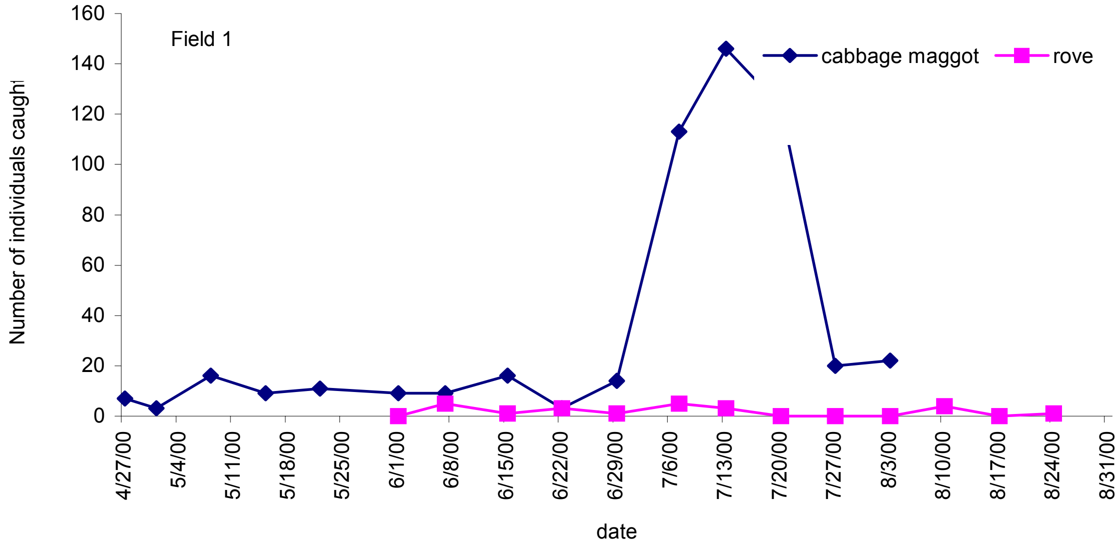

Figure 7 a (above) and b (below). Rove beetle and cabbage maggot trap catches in individual fields. Cabbage maggot counts are sums from two traps per week. Rove beetle counts are sums from five traps per week.

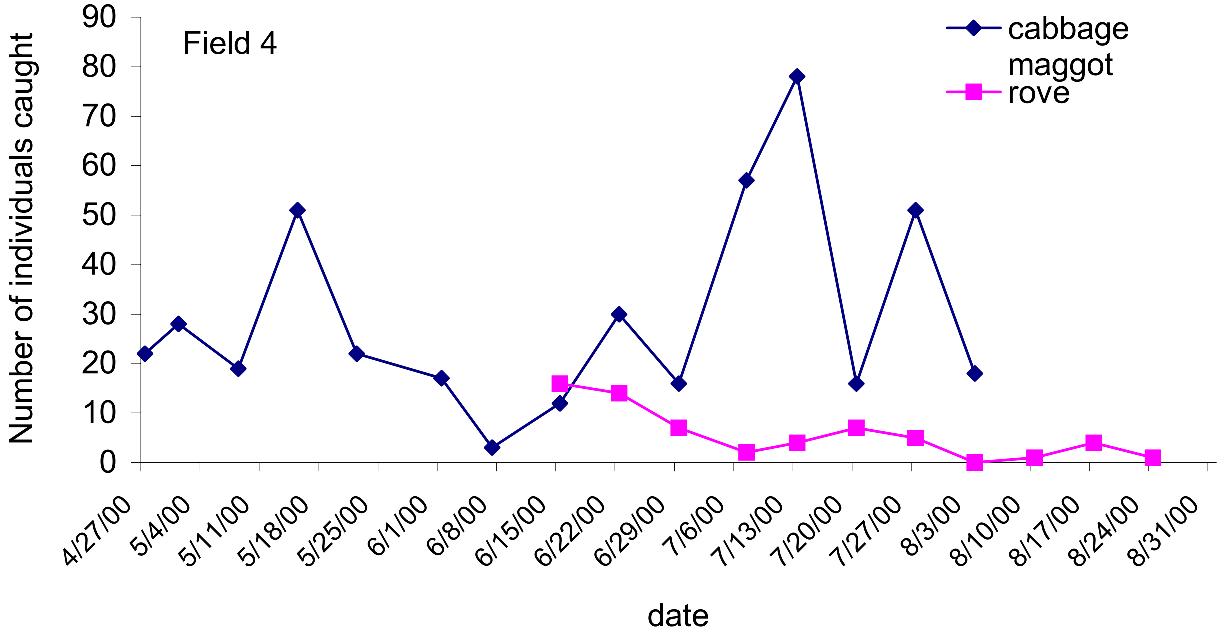
Field 4
cabbage maggot
rove
Number of individuals caught
0
10
20
30
40
50
60
70
80
90
4/27/00
5/4/00
5/11/00
5/18/00
5/25/00
6/1/00
6/8/00
6/15/00
6/22/00
6/29/00
7/6/00
7/13/00
7/20/00
7/27/00
8/3/00
8/10/00
8/17/00
8/24/00
8/31/00
date

Figure 8. Examples of grass margins typical of agricultural fields in south western British Columbia. The picture on top is from Field 1 and the lower picture is from Field 4.

Figure 9. Examples of tree and shrub margins typical of fields in south western British Columbia. The picture on the left is from Field 3 and the one on the right is from Field 5.

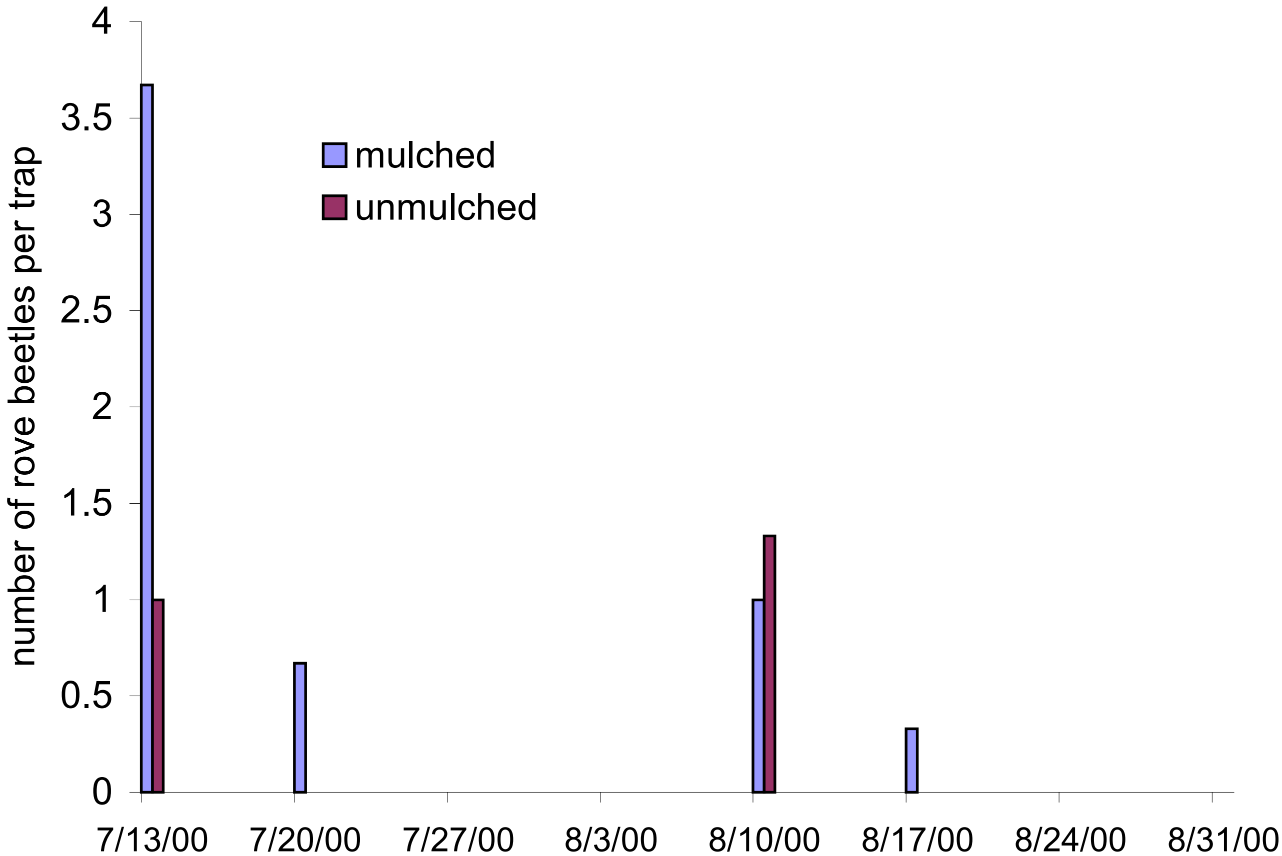

Figure 10. Rove beetle catches in pit fall traps placed per trap in mulched vs unmulched plots. Total number of traps for mulched was 3 and for unmulched was 5.

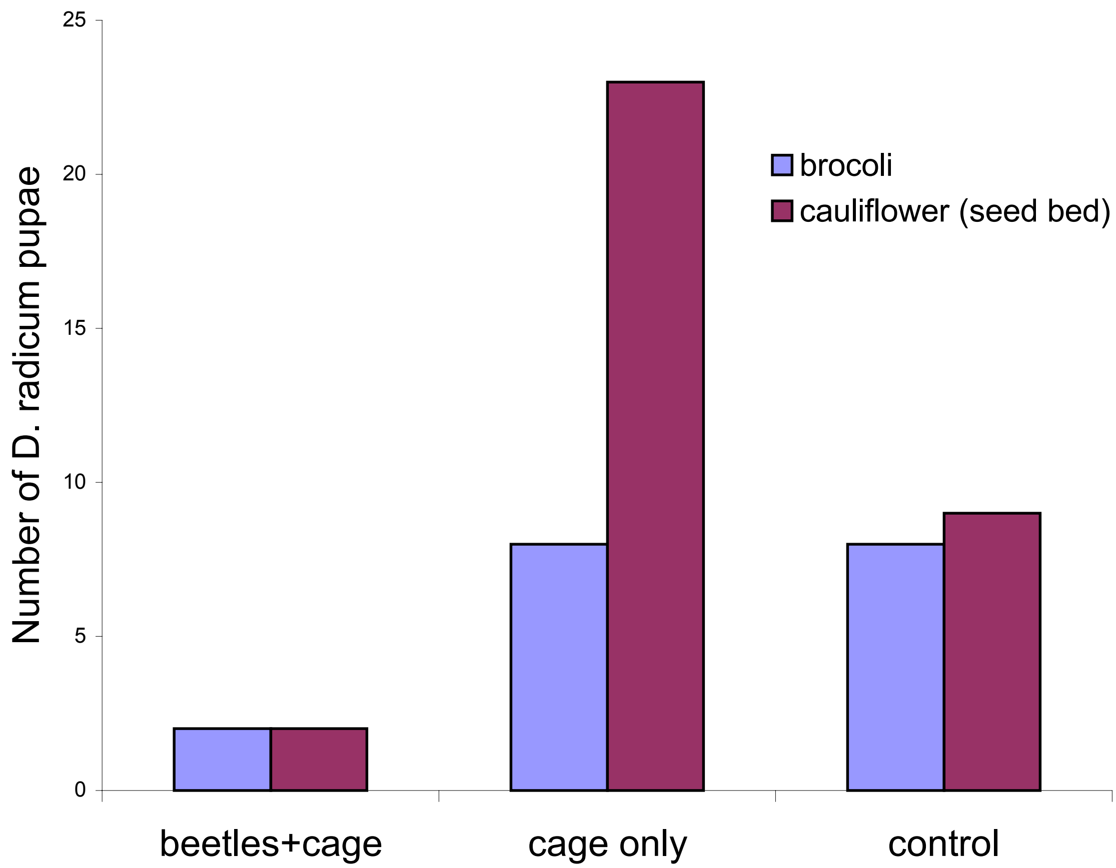

Figure 11. Effect of beetle introduction versus no beetle introduction on cabbage maggot populations. Plots were 30-cm in diameter and contained 1 plant (broccoli) or 14 plants (seed bed). Each bar represents the sum of 2 replicates.