CAN PSYLL NET

Newsletter of the **Canadian Potato Psyllid and Zebra Chip Monitoring Network**

- December 2017 -

Growing Forward 2, Project: Zebra Chip and Potato Psyllid Survey and Monitoring

Dan Johnson, Larry Kawchuk, Scott Meers, and Network Participants

To Current and Potential Participants

Lso (zebra chip pathogen) has been detected in small numbers of potato psyllids in two sites in Alberta, but no zebra chip symptoms or pathogen has been found in any potato plant tissue yet.

First, as noted in the August newsletter, we thank all network members, project staff, and volunteers, including those who send us sampling cards to examine, and those who have their own programs but stay in touch with our recommendations and newsletters.

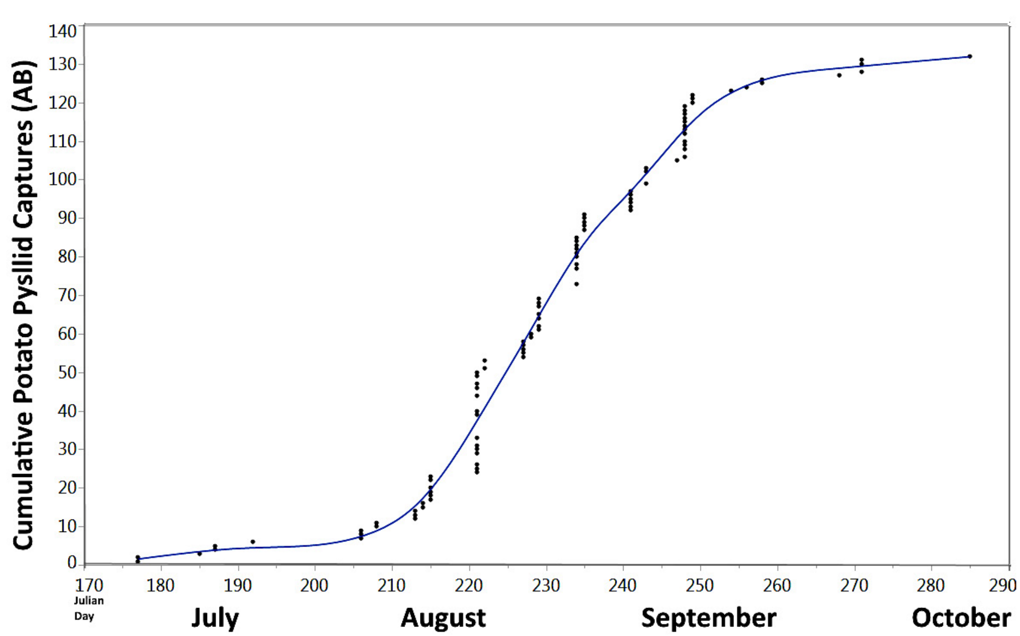
Update:
During three years of sampling for potato psyllids (*Bactericera cockerelli*) across Canada, we found small numbers in Alberta (2015-2017, increasing annually), Saskatchewan (first time in 2016), and Manitoba (first adults, 2016). No potato psyllids have been found on sample cards from any sites east of Manitoba.

Dan Johnson

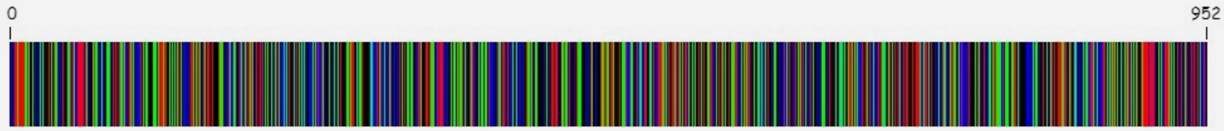
In southern Alberta, the range of potato psyllids has expanded to sites throughout the potato-growing area, where in 2017 they appeared on sampling cards of over 70% of 45 sites regularly sampled (we thank the growers for cooperation and access to University of Lethbridge samplers at 45 sites, with a minimum of 4 sampling cards per field, and Crop Diversification Centre South for managing two additional sites and sending sample cards). Potato psyllids, although not found in Canada during 2014 and previous years, are now well established at very low levels, but have increased in abundance during 2015-2017. In Alberta, most fields have very low populations. In our sampling program, the sampling cards are examined, and the numbers of potato psyllids, other psyllids, and key natural enemies of psyllids, aphids, and thrips, are recorded. Numbers of potato psyllids remain very low throughout the area, but higher average counts and individual sample counts as high as 6 potato psyllids on one sample card in the sites we monitor indicate that the population is increasing, compared to 2016 and 2015.

Now for the first time, after testing almost 1000 psyllids, the Lso pathogen, *Candidatus* Liberibacter solanacearum, that causes zebra chip disease has been detected. The results are from DNA analysis conducted in the Kawchuk lab of the Lethbridge Research Centre, from psyllids found on sampling cards examined in the Johnson lab at the University of Lethbridge. So far, it has appeared in small numbers of potato psyllids.

The initial detections were from one site, south of Highway 3, monitored by the University of Lethbridge, so we took steps to increase sampling intensity. A week later, potato psyllids from a well separated second site, north of Highway 3, also tested positive, indicating that it is likely that we have a widespread incidence of Lso at a very low level, rather than a single random arrival or importation. Subsequently, psyllids submitted by Promax Agronomy also tested positive. We are conducting more collections (with sample examinations and insect identification done at the University of Lethbridge) and DNA testing (AAFC, LRC) to determine when and if the positive detections will decline in numbers. Potato psyllids, free from Lso, have also been found in at least two greenhouses (where they also infest peppers and tomatoes). The possibility of importation on plant material and subsequent transfer of Lso to our resident potato psyllid population is also being considered.



▲ Cumulative number of potato psyllids per card in Southern Alberta (45 sites, map available) from June to October 2017.



The nucleotide sequence of the 16S ribosomal RNA transcript of Lso (*Candidatus* Liberibacter solanacearum), found in Alberta in late 2017.

Green: adenine (A) Black: guanine (G) Blue: cytosine (C) Red: thymine (T)

The Lso pathogen was detected and identified by the Kawchuk lab at the Lethbridge Research and Development Center, Agriculture and Agri-Food Canada, from at least 6 potato psyllids (*Bactericera cockerelli*) collected and identified by the University of Lethbridge (Johnson Lab, Water and Environmental Science Building), in regularly sampled potato fields (detected at one main site, of 42 separate fields) in southern Alberta south of Highway 3. Subsequently, potato psyllids collected at two sites north of Highway 3, managed by Crop Diversification Centre South, Brooks, Alberta, tested positive for Lso. Further testing later detected Lso in potato psyllids submitted by Promax Agronomy Services Ltd., from Alberta.

▲ Egg of potato psyllid on a developing leaflet.

▲ Potato psyllid nymphs.

Sequences of the Lso (Kawchuk lab, LRC) show 100% similarity to Lso isolates from the Pacific Northwest, USA, indicating probable similar pathogenicity. Only a small proportion of the potato psyllids collected in Alberta field sites have Lso, and laboratory work continues to work through and characterize samples of potato tissue as well the vector status and possible origins of as any additional potato psyllids captured in 2017.

It is important to note that potato psyllid numbers in all Alberta sites are very low, with many cards capturing none. Sweep net and vaccum sampling almost never finds any in Alberta. In other regions, zebra chip does not normally become a problem unless the potato psyllids are found at much higher numbers than are currently found in Canada. The next steps will include further testing, but so far no zebra chip has been detected. We initially informed the potato growers, Potato Growers of Alberta, and Canadian Horticultural Council so they could circulate this information and discuss the implications.

Our recommendations:

1) Increased monitoring for potato psyllids near collection sites where Lso was detected.

2) Monitoring in other ways, such as nets, vacuums, weed examination, and plant examination/collection, for overwintering potato psyllids in nearby fields should be stepped up during harvest and post-harvest season, and monitoring should be conducted on surrounding vegetation after harvest to detect overwintering potato psyllids.

3) Plant samples, including harvested potatoes, should be tested from these sites, although it is very unlikely that zebra chip occurs in these yet.

4) Managers should be aware of the need for monitoring stored potatoes.

5) Growers and managers should be reassured that the numbers of potato psyllids and the incidence of Lso are both currently low. So far, no zebra chip has been found in potatoes in Canada.

6) Monitor potential natural enemies should continue, with efforts to determine to what extent they could reduce future potato psyllid numbers. Natural enemy numbers can be sampled from the same cards as the potato psyllids, with additional collecting methods where required. For example, here is a summary of our counts on a selection of sticky cards from 2017, examined in the Johnson lab:

Potato psyllids, 133
(plus >100 from greenhouse samples)
Other psyllids, 829
Natural enemies (predators):
Minute Pirate Bug, 1528
Damsel bugs, 302
Lacewings, 268 (2 species)
Ladybird beetles, 873 (13 species)

We wish to acknowledge the support of Growing Forward 2, AAFC, Canadian Horticultural Council, Potato Growers of Alberta, Alberta Agriculture and Forestry, Lethbridge Research Centre, University of Lethbridge, and the network of volunteers who sample in Alberta and across Canada.

▲ In addition to sampling and monitoring the potato psyllid and potential natural enemies, we identify and monitor some other psyllids, including green psyllids, which are often found in and around potato fields. During 2014-2017, we also have observed and monitored the relatively rare Morning glory psyllid *Bactericera maculipennis* (sometimes found on or near field bindweed, *Convolvulus arvensis*), which may also have a relationship to the Lso bacterium. It is easily distinguished from potato psyllid by the brown spots on the wing.

Background

Zebra chip is a disease of potatoes documented in the western USA, Mexico, Central America, and New Zealand. The disease severely disrupts carbohydrate flow in potato plants, resulting in a striped appearance in tubers. The pathogen, *Candidatus* Liberibacter solanacearum (Lso), is transmitted by the potato psyllid, *Bactericera cockerelli*, a flying insect 2-3 mm in length. Feeding by immature stages of potato psyllid can also causes a disease called 'psyllid yellows'.

The objective of this project and network is to survey fields for populations of the potato psyllid in Canada, and test captured potato psyllids and symptomatic tubers for the presence of the disease agent, Lso. The network of researchers and collaborators participates in conducting field sampling, identifying species and stages, mapping occurrence if found, developing and implementing a monitoring program, assessing the effects of weather and regional variations and movements, determining potential geographic range, constructing a geographic forecasting model of the insect life history and development, and developing a management plan. We have located the potato psyllid, previously rare or unknown, in Alberta at numerous locations during 2015-2017, and in 2016 we found it in Manitoba and Saskatchewan. In 2017, potato psyllids were found in Alberta in the June 13-23 field samples. Sample cards have arrived from New Brunswick, and additional sample cards are expected to arrive from Manitoba, Saskatchewan, Ontario, Quebec, and British Columbia.

Adult specimens of potato psyllids collected during 2015-2017 did not appear to have undergone long-distance flights. Timing indicated probable local populations, with possible augmentation by migrants in special cases. Accidental importation has occurred in the past. Analysis of cytochrome c oxidase subunit 1 (COI) of individual potato psyllids (Kawchuk lab, Lethbridge Research Centre) indicated that Central and Western haplotypes are both present in southern Alberta. With DNA analysis of specimens to detect presence of Lso and to determine *Bactericera cockerelli* haplotypes. Experiments and collections of potential natural enemies have been conducted, and weather variables have been compiled for application in forecasting.

▲ Immature potato psyllid

▲ Adult potato psyllid found in Manitoba.
(Bisht, Vikram, Johnson, Dan, Kawchuk, Larry, and Meers, Scott. Occurrence of potato psyllids in Manitoba, PMR Report: Section C- Insect Pests 2016)

How to sample

Potato psyllids can be sampled with a gas-powered vacuum, or with a fine-mesh insect net. The immature stages and eggs can be counted on the undersides of leaves. However, a more standard, passive sampling method involves staking yellow sticky cards above the crop so that leaves do not touch the card. The cards are placed on stakes, four per field and usually about 5 to 20 m into the crop from the edge. After one week, or longer in cool or cloudy weather, the cards are picked up and replaced with new cards. Potato psyllids may be found during examination under the microscope. We examine up to 2000 cards per year at the University of Lethbridge.

Potato psyllids have a one-into-three main branch in the wing venation, white stripes on abdomen, and light sculpturing on the thorax.

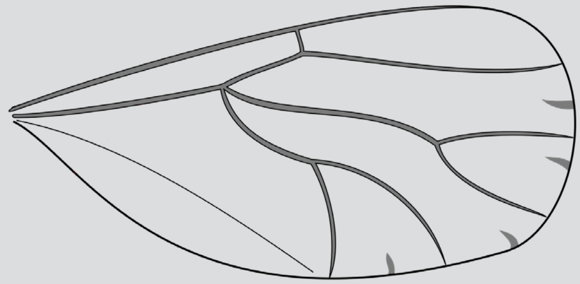
▲ Newly emerged adult potato psyllid

◂ When potato psyllid adults emerge, they are often white or yellow. During the first few hours they dry and darken, and the usual pattern with sculptured lines on the thorax and head and two white strips on the abdomen is apparent.

▲ Psyllidae (not potato psyllid)

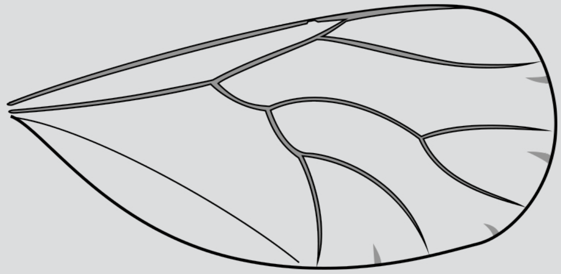
Psyllids have a head that is separate from the thorax, and long, clearly segmented antennae (unlike leafhoppers, which typically have heads that are more continuous with the body, and short, fine antennae).

◀ Triozidae (potato psyllid)



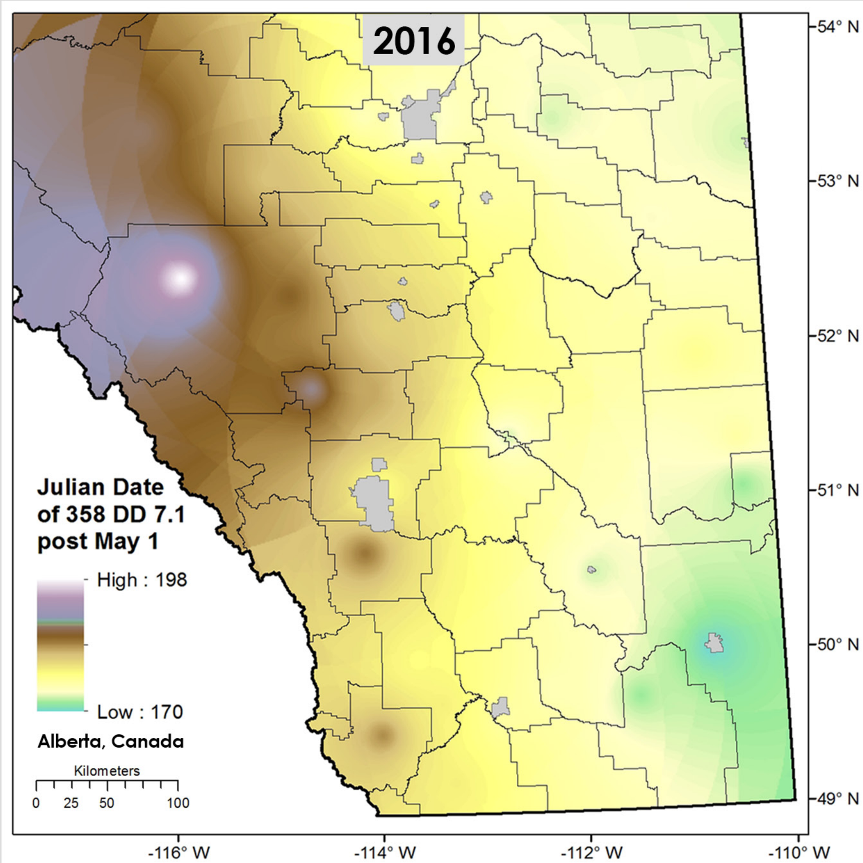
◀ Potato psyllids are in the family Triozidae, which have wing venation that branches into three.

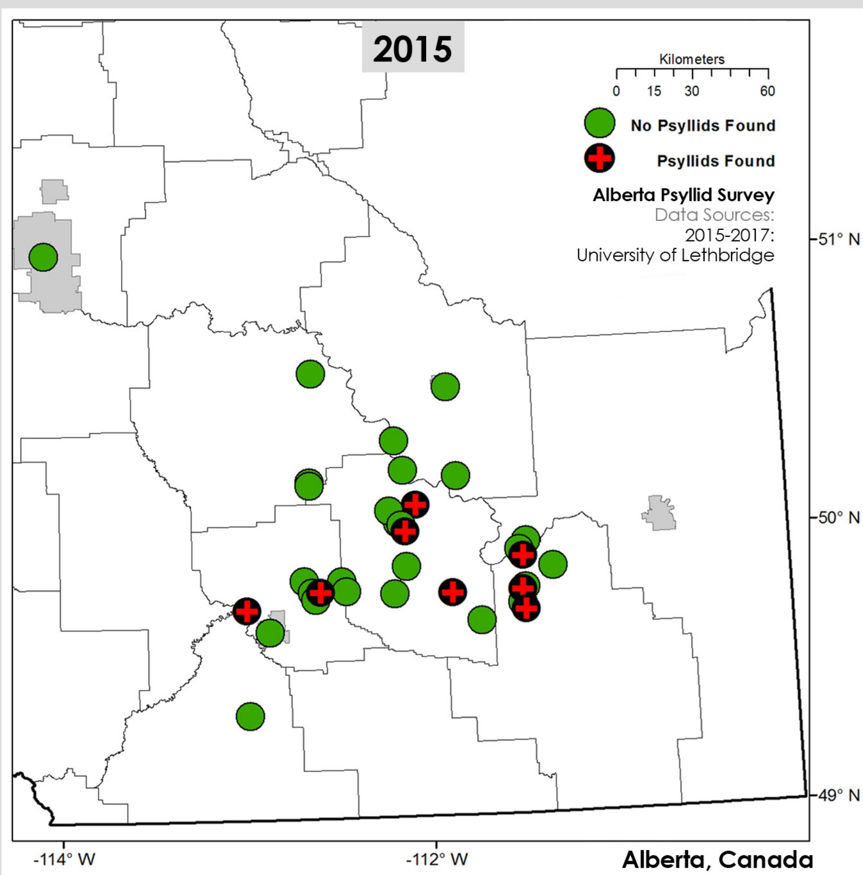
(Image Source: Wikipedia)



◀ There are many psyllids in the family Psyllidae, easily recognized by the branching into two.

(Image Source: Wikipedia)



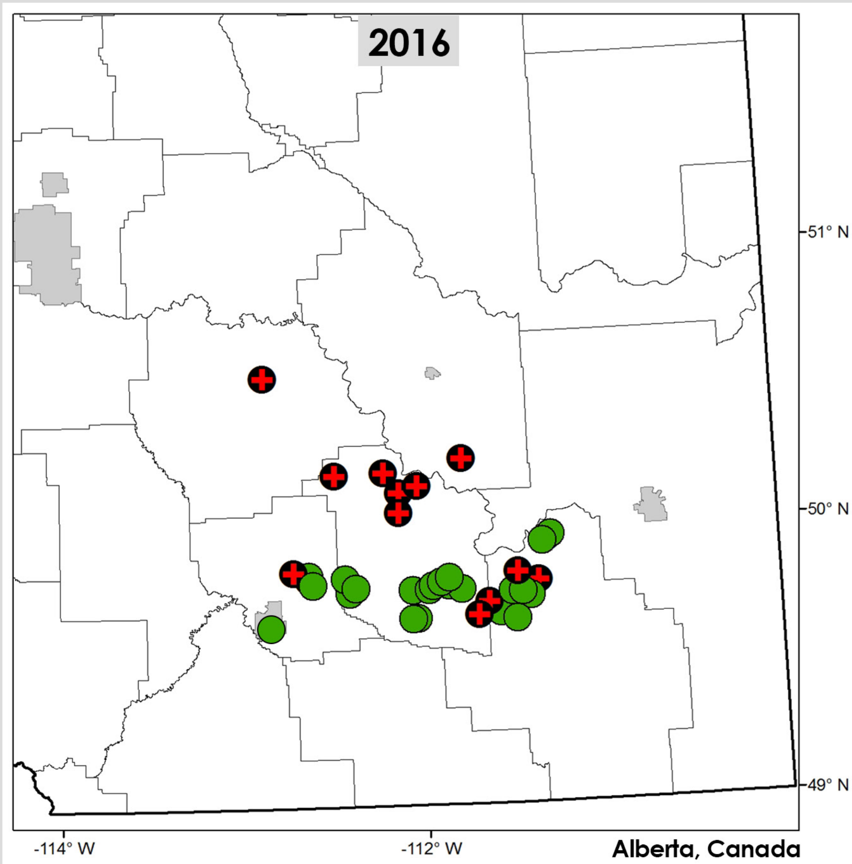


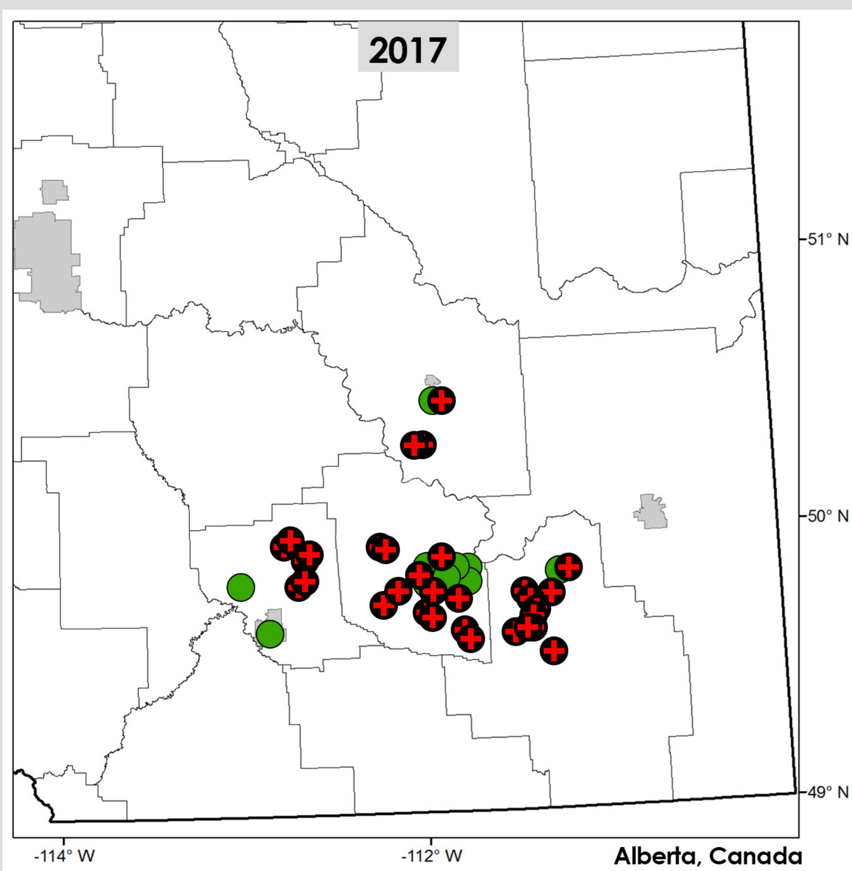
The body temperature of insects determines rates of development, maturation, feeding, and egg-laying. Insects can seek warmer or cooler habitat in vegetation, but in general the daily air temperature is an estimate of insect body temperature. Lab experiments indicate how much heat is required to complete a stage or a generation. Tran et al. (2012) estimated a potato psyllid life requirement of 358 degree-days above 7.1 °C. Degree-day accumulations are mapped and compared. The Julian date (count from January 1) on which 358 DD7.1 is reached serves as an index.

Tran, L.T., Worner, S.P., Hale, R.J. and Teulon, D.A. (2012). Estimating development rate and thermal requirements of *Bactericera cockerelli* (Hemiptera: Triozidae) reared on potato and tomato by using linear and nonlinear models. Environmental Entomology, 41, 1190-1198.

Agriculture and Agri-Food Canada
Growing Forward 2
Canadian Horticultural Council
PGA POTATO GROWERS OF ALBERTA
Alberta Government
ACIDF Alberta Crop Industry Development Fund Ltd.
University of Lethbridge
FIAT LUX

▲ Map data and GIS: Dan Johnson, Celeste Barnes, Christian Sapsford, Qing Xia, Peter Kennedy





These maps show the locations of the sites monitored in Alberta, for which locations and results were provided to the network. We thank the growers and landowners for access permission.

At each site, four yellow sticky cards were placed on stakes in a potato crop. We change the cards every week or two, depending on weather. The red crosses on these maps indicate fields in which potato psyllids were captured during the year shown. Potato psyllid captures have occurred during the period June 13 to Sept 30.

Kilometers
0 15 30 60

No Psyllids Found

Psyllids Found

Alberta Psyllid Survey
Data Sources:
2015-2017:
University of Lethbridge

Agriculture and Agri-Food Canada
Growing Forward 2
Canadian Horticultural Council
PGA Potato Growers of Alberta
Alberta Government
ACIDF Alberta Crop Industry Development Fund Ltd.
University of Lethbridge
FIAT LUX

▲ Maps: Dan Johnson, Celeste Barnes, Christian Sapsford, Qing Xia, Scott Meers, Lary Kawchuk

Update on sampling in Canada

1. Alberta: Over 200 potato psyllids were found in 2016, plus additional captures from non-potato sources. From the University of Lethbridge lab, we set up and monitored 29 potato fields in 2016 and 42 fields in 2017, plus field sites by Alberta Agriculture and Forestry. Network participants sampled across Canada, and sent the cards to be examined. Additional sampling was conducted in Alberta by Promax Agronomy, a private company in AB, and gardeners.

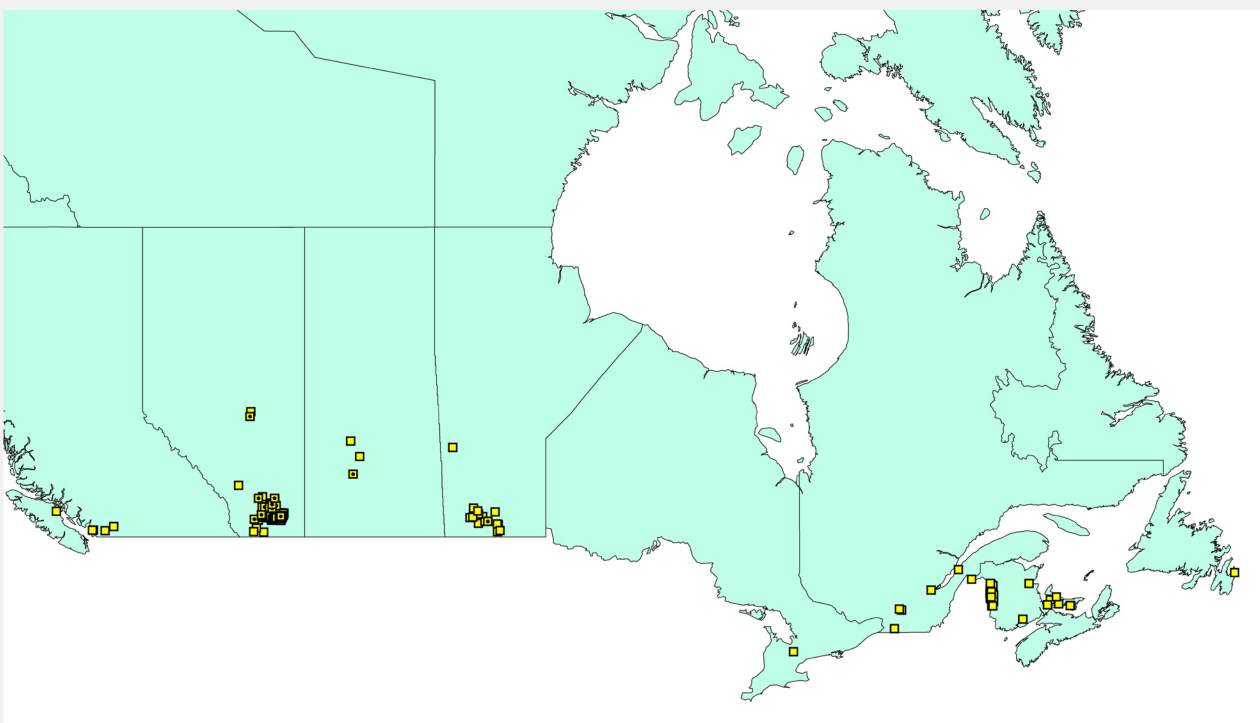
2. Manitoba and Saskatchewan: The network received cards from Manitoba and from sites in Saskatchewan (see network list). We found potato psyllids on cards from both.

3. Other provinces: Potato psyllids tend to have a mainly western distribution, but sampling east of Manitoba provides valuable data on range and possible expansion. We have extensive data from New Brunswick, and smaller samples from other provinces.

Sampling card examined at the University of Lethbridge:

Province	**2015**	**2016**	**2017**
AB	998	1384	1307
BC	1152	73	TBA
MB	141	113	156
ON	6	0	86
NL	0	3	0
PEI	0	8	0
QC	38	3	0
SK	11	14	19
NB	546	486	488
TOTAL	2892	2084	2056

We prepared GIS maps of the potato psyllids found. Environment Canada and Alberta Agriculture and Forestry have provided weather data for current and historical analysis.



▲ Canadian potato field sites surveyed for potato psyllid between 2014-2017, known locations. Potato psyllids were found in Alberta, Saskatchewan, and Manitoba.

Natural Enemies

Natural enemies play a role in regulating numbers of leafhoppers, aphids, psyllids, and other small insects. Low level of insecticide use in potato fields allows a diverse community of natural enemies to exist. The immatures and adults of small insects, including psyllids, are attacked by jumping spiders, crab spiders, large and small predaceous beetles, lacewings, ladybird beetles (multiple species), several species of predaceous bugs, ants, and hymenopterous parasitoids.

Green Lacewing

Two-spot Ladybird Beetle

Damsel Bug

Damsel Bug preying on Hoverfly

Rove Beetle and parasitoid wasps

wasp

Minute Pirate Bug

We have also monitored thirty species of common predators of small insects in potato fields. Minute Pirate Bugs and Lady Beetles (a.k.a. Ladybug or Ladybird) are known to eat large numbers of immature potato psyllids (confirmed in the lab). Our samples (three-year field study by Christian Sapsford and Dan Johnson) indicate that these predators are at levels that could significantly reduce psyllid numbers. The numbers of these predators declined in 2016, cause unknown. Among lady beetle species, Thirteen-spotted Lady Beetle, Convergent Lady Beetle, Seven-spot Lady Beetle, and Parenthesis Lady Beetle were the most common.

Brumoides Septentrionis
(Weise, 1885)
Winter lady beetle

Hippodamia sinuata
(Mulsant, 1850)
Sinuate lady beetle

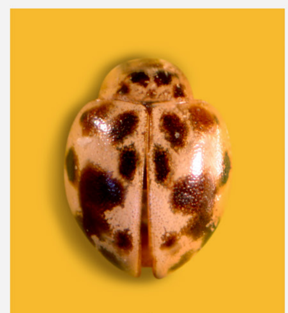
Hippodamia parenthesis
(Say, 1824)
Parenthesis lady beetle

Hippodamia convergens
(Guérin de Méneville 1842)
Convergent lady beetle

Hippodamia glacialis
(Fabricius, 1775)
Glacial lady beetle

Hippodamia expurgata
(Casey, 1908)
Expurgate lady beetle

Coccinella transversoguttata
(Faldermann, 1835)
Transverse lady beetle



Psyllobora vigintimaculata
(Say, 1824)
Wee-tiny Lady Beetle

Hippodamia tredecimpunctata
(Linnaeus, 1758)
Thirteen-spotted lady beetle

Coccinella septempunctata
(Linnaeus, 1758)
Seven-spot lady beetle

Adalia bipunctata
(Linnaeus, 1758)
Two-spot lady beetle

Hyperaspis undulata
(Say, 1824)
Undulate lady beetle

▲ Microscope photos: Christian Sapsford, Zeiss Stemi 2000-C

Lady beetles on sticky cards in Alberta potato fields

Year	Number of cards	Number of lady beetles	Number of species	Average number of lady beetles/card	Sites surveyed
2015	627	1157	10	1.8	32
2016	551	132	10	0.2	40

Lady beetles in sweep net samples in Alberta potato fields

Year	Number of bags	Number of lady beetles	Number of species	Average number of lady beetles/bag	Sites surveyed
2015	63	126	7	2.3	4
2016	65	117	5	2.5	10

◂ Seven-spot Lady Beetle feeding on immature psyllids. In experiments, we found that lady beetles (also called ladybird) can consume hundreds of immature psyllids per day, under the right conditions, but rarely capture adult psyllids. Lady beetles typically feed on aphids and other small insects, but could also reduce numbers of potato psyllids that manage to reproduce on potato plants.

Why Monitor Psyllids and Lso Pathogen?

Zebra chip (ZC) is an economically costly disease of potatoes, documented mainly in the western USA, Mexico, Central America, and New Zealand (Horton et al., 2015). It is caused by a pathogen, *Candidatus* Liberibacter solanacearum, transmitted during feeding by the potato psyllid, but not by other insects. Plant growth, yield and quality are strongly affected, and the striped appearance of affected tubers reduces value for processing. Other symptoms of the infected plant include leaf deformity, chlorosis, bud proliferation, and yellow or purple discoloration (Munyaneza et al., 2007; Munyaneza, 2012). The disease can result in loss of crops, and infection of stored tubers. Potato psyllid populations are now found in Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Texas, Utah, Washington, Wyoming, and, since this study, Alberta, Saskatchewan, and Manitoba.

Zebra chip presents a potential high economic risk to potato production. Estimates in other regions indicate severe impacts. For example, Greenway (2014) found that eastern Idaho would suffer a 55% reduction in returns for potato producers, and predicts an “inability of Pacific Northwest growers to sustain a profit if they adopt a routine insecticide program for ZC protection that begins at plant emergence.”Annual losses in Texas have been reported in the range US $25 to $30 million (Texas A&M AgriLife Research & Extension, 2016).

Potato psyllids are known to move in response to warm weather. Warmer conditions may allow expanded movement into Canada, and better establishment because of accelerated development and increased survival.

In 2013, we began field sampling and organized monitoring in order to support a more informed response if the insect vector becomes established in potato-growing regions in Canada. An efficient pest surveillance program would reduce or prevent yield and quality losses caused by the transmitted chip disease, and provide a more competitive product. Small numbers of adult potato psyllids were found in Alberta in 2015, increasing in 2016 and 2017. Detection of the Lso bacterium is done in the lab with PCR DNA analysis.

Network participants are currently sampling for potato psyllids across Canada, from coast to coast. Other research includes analysis to predict the likely zones of establishment, and consideration of alternate host plants. Potato psyllids are capable of living on some weeds and other vegetation, and in some cases have been shown to transmit Lso to them (Murphy et al., 2014). We do not yet know how they might interact with weeds and native plants found in Canada.

To obtain sampling cards, contact dan.johnson@uleth.ca

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Current Network Participants in Canada

Alberta:

University of Lethbridge:
- Dan Johnson (Network Coordinator)
- Qing Xia (MSc student on the project; graduated October 2017)
- Sampath Walgama (Research Associate)
- Christian Sapsford (Research Assistant)
- Celeste Barnes (GIS)
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- Daya Gaur, graduate committee; collaborator, weather and insects
- James Byrne, graduate committee; collaborator, weather and insects
- Peter Kennedy, collaborator, weather data and insects
- Mahsa Miri (Graphic Designer)

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Eugenia Banks, Ontario Potato Board, Guelph
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Laure Boulet, Conseillère régionale en horticulture, Ministère de l'Agriculture, Rivière-du Loup
Patricia Masse, Les Fermes MVG Inc., Nadia Surdek, Saint-Thomas de Joliette

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Jazeem Wahab, Canada-Saskatchewan Irrigation Diversification Centre, Outlook
Greg Larson, Canada-Saskatchewan Irrigation Diversification Centre, Outlook
Sean Prager, Department of Plant Sciences, University of Saskatchewan, Saskatoon

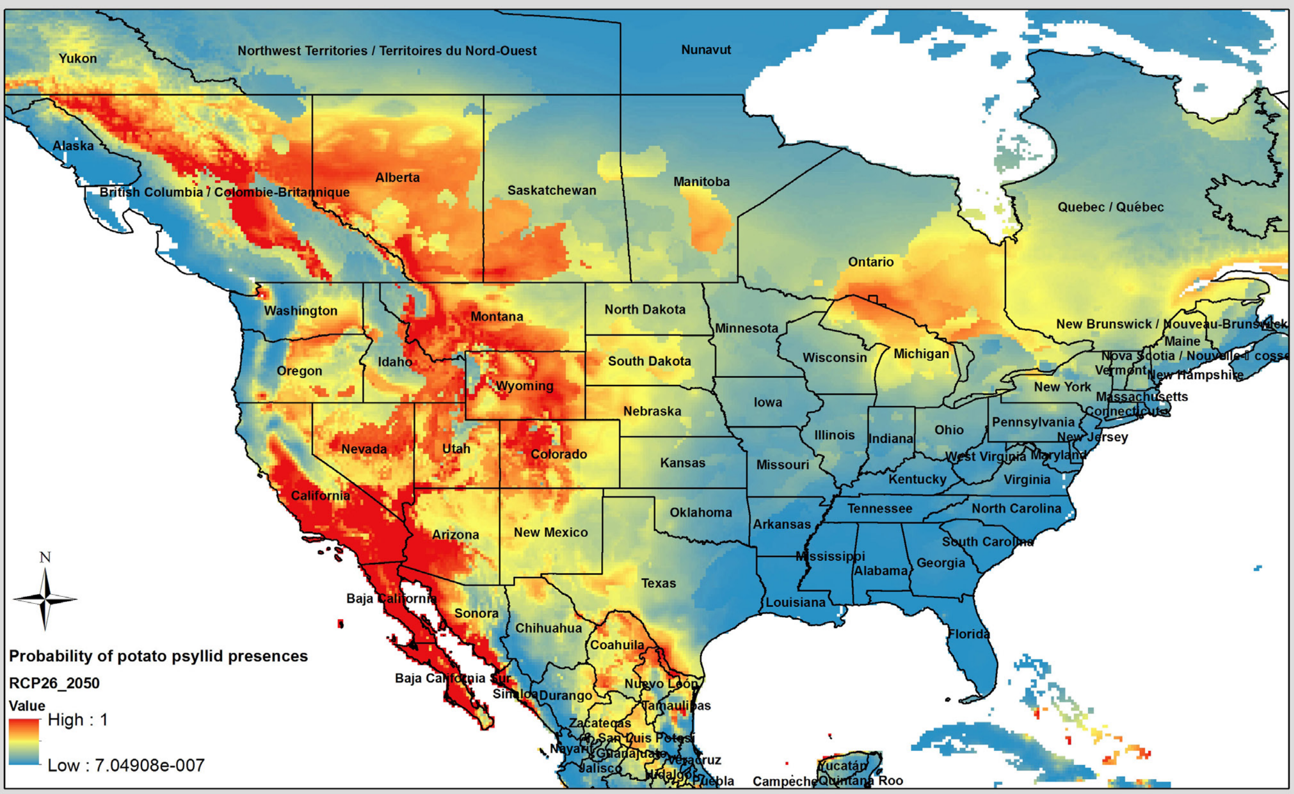
And Canadian Horticultural Council: David Jones, Amy Argentino, and staff

▲ Potato psyllid eggs

▲ Adult potato psyllids

Even without the Lso bacteria, potato psyllids have been known to cause severe yellowing of leaves.

Graduate student Qing Xia (Summer Xia) at the University of Lethbridge used historical field survey records of the plant disease psyllid yellows as a way to find and compile the locations and dates of potato psyllid infestations of previous years back to the 1930's, and then compare the presence and absence of the condition (caused by immature potato psyllids) to weather and climate. She is using the results to determine whether climate variables, like annual temperature and precipitation, can be used to identify regions in which the potato psyllid is most likely to invade. Finer-scale weather data could then be used to model the timing and development of the populations where they can be found.



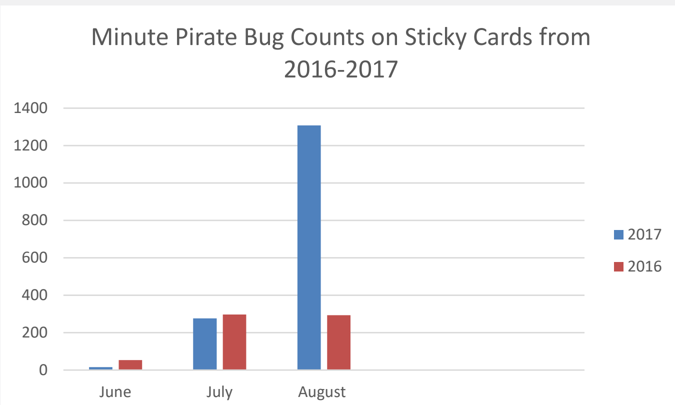
▲ This map is an example of simulation projections of how the area that will allow survival of potato psyllids could move north under standard climate forecast scenarios (example model output based on WorldClim and CLIMDEX databses). This shows the geographical distribution of potato psyllid presence probability in North America, projected to the BIOCLIM layers generated using the RCP2.6, 2050 climate data.

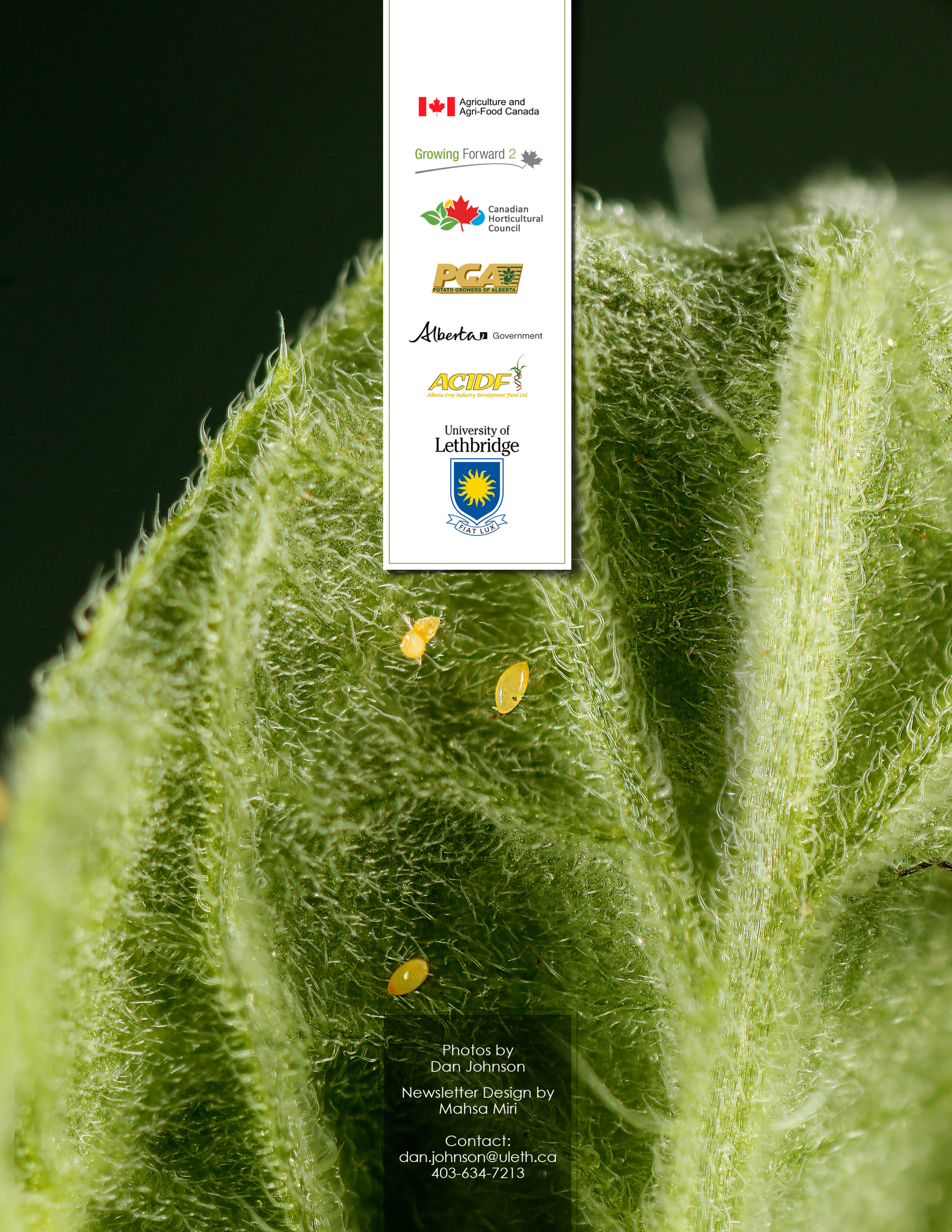
Example of other studies

Minute Pirate Bug (*Orius*) is a small predaceous bug that is known for killing large numbers of thrips, mites, aphids, and psyllids of all kinds. We have been monitoring the numbers of this predator on the same cards that collect potato psyllid samples. Most cards have 0, 1, or 2 Minute Pirate Bugs, but in some cases up to 20 per card are recorded, indicating very healthy and active predator populations.

2016	MPB	Cards	MPB/Card
Jun	53	222	0.24
Jul	296	273	1.08
Aug & Sep	293	173	1.69

2017	MPB	Cards	MPB/Card
Jun	15	136	0.11
Jul	162	214	0.76
Aug & Sep	1307	569	2.30





Agriculture and Agri-Food Canada

Growing Forward 2

Canadian Horticultural Council

PGA POTATO GROWERS OF ALBERTA

Alberta Government

ACIDF Alberta Crop Industry Development Fund Ltd.

University of Lethbridge

FIAT LUX

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