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First records of the resin bees, *Dianthidium pudicum pudicum* and *D. simile* (Hymenoptera: Megachilidae), in Manitoba, with a key to local species

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Abstract – Here we present the first provincial records of the genus *Dianthidium* occurring in Manitoba. Records from multiple sites are documented for the western bee *D. pudicum pudicum* that represent the northeastern limit of its range in North America. In contrast, new records of the eastern species *D. simile* in Manitoba constitute the northwestern range limit of that species. Both species are illustrated and a key is provided to facilitate future recognition.

Introduction

Dianthidium Cockerell (Megachilidae: Anthidiini) is a genus of chalicodomiform bees endemic to North America. *Dianthidium* spp. are solitary bees and use plant resins in nest construction (Hicks 1927, 1933; Frohlich and Parker 1985; O'Brien 2007). No members of *Dianthidium* have been recorded from the province of Manitoba. Three species have been recorded from neighbouring states and provinces in online sources (www.discoverlife.org).

Dianthidium (*Dianthidium*) *pudicum pudicum* (Cresson, 1879) is found in open habitats in western North America. There are records of the nominal subspecies from Mexico (<http://www.discoverlife.org/mp/20l?id=KSEM307326>) and California north to British Columbia (Schwarz 1928; Grigarick and Stange 1968; Hurd 1979) and east into Saskatchewan (C. Sheffield, *pers. comm.*) and North Dakota (http://www.discoverlife.org/mp/20l?id=AMNH_BEE00165388). Specimens have been collected in a variety of habitats, including mountain areas (Grigarick and Stange 1968) and desert or dry shrubland (Wilson *et al.* 2008).

Dianthidium pudicum is a solitary, polylectic species with two recognized subspecies. Floral associations are primarily within the families Asteraceae and Fabaceae, but numerous other associations have been recorded, primarily for the subspecies, *D. p. consimile* (Ashmead, 1896) (Hurd 1979; <http://discoverlife.org>). The nominal subspecies has cream to white maculations and *D. p. consimile* has yellow maculations (Grigarick and Stange 1968). Nests are constructed using a combination of pebbles and plant resins adhered to rocks (Hicks 1927) or in the forks of branches (Grigarick and Stange 1968; Clement and Rust 1974).

Dianthidium (D.) simile (Cresson 1864) is a ground-nesting species that mixes plant resins with sand grains and plant debris to construct cells (O'Brien 2008). Shallow nests (1–5 cm) are built in small aggregations in lacustrine habitats near the base of grasses (O'Brien 2008). Records of *D. simile* come from Minnesota, Ontario, and south to Georgia (Mitchell 1962; Hurd 1979; Romankova 2003). The nearest documented records to Manitoba are from Sudbury, Ontario in Canada (Evans, 1896; Schwarz 1928; Romankova 2003) and Cass County, Minnesota in the USA (<http://bugguide.net/node/view/212136/bgpage>).

One other species *D. (D.) curvatum* (Smith 1854) has been recorded from Alberta (Sheffield *et al.* 2014) and North Dakota (http://www.discoverlife.org/mp/20l?id=AMNH_BEES16604), but is not known from Manitoba.

Here we present new records of occurrence for *D. p. pudicum* and *D. simile*, the first for Manitoba.

Materials and Methods

Collections using an aerial net were made by S. Semmler on 30 July 2014 in Rotary Prairie Nature Park, Winnipeg, Manitoba (49.898, -97.034, elevation approx. 230 m). Rotary Prairie consists of approximately eight hectares of remnant tall grass prairie, marsh/sedge meadow, stands of willow, and aspen forest. The park is surrounded by industrial and residential development. The collection was made on purple prairie clover (*Dalea purpurea* Vent.; Fabaceae) in a dry section of tall grass prairie southeast of an aspen forest edge. Numerous species of flowering plants occur in this site, including prairie sunflower (*Helianthus pauciflorus* Nutt.; Asteraceae), dwarf milkweed (*Asclepias ovalifolia* Decne.; Apocynaceae), black-eyed Susan (*Rudbeckia hirta* L.; Asteraceae), bottle gentian (*Gentiana andrewsii* Griseb.; Gentianaceae), and Canada thistle (*Cirsium arvense* L.; Asteraceae).

Collections using coloured pan traps (blue, yellow, white) were made by M. Olynyk in 2014–2015 on property owned and managed by the Nature Conservancy of Canada 5 km south of St. Lazare, Manitoba, approximately 4 km east of Provincial Highway 41 (50.403, -101.309, elevation approx. 465 m). Habitat consisted of upland tame grass pasture dominated by crested wheatgrass (*Agropyron cristatum* (L.) Gaert., seeded >25 years previously) with low-density floral resources in sandy soils. The pasture was bordered by hardwood forest on graded slopes dominated by oak, poplar, and various

shrubs. The site was managed by rotational cattle grazing. Flowering plants included common yarrow (*Achillea millefolium* L.; Asteraceae) harebell (*Campanula rotundifolia* L.; Campanulaceae), fleabane (*Erigeron glabellus* Nutt.; Asteraceae), alfalfa (*Medicago sativa* L.; Fabaceae) and Canada thistle (*C. arvensis*).

Specimens were collected as part of an ongoing survey of pollinators in the Tall Grass Prairie Preserve (Rural Municipality of Stuartburn, 49.155, -96.740, elevation approx. 290 m) by R. Miller in July and August 2017. Collections were made using coloured pan traps at a prairie-wet meadow/carr site, which has been used for cattle grazing as recently as 2011. Nearby floral resources included swamp milkweed (*Asclepias incarnata* L.; Apocynaceae) and black-eyed Susan (*R. hirta*).

A combination of netting and coloured pan traps were used by J. Gibbs and G. Yuko Nozoe to sample bees at Birds Hill Provincial Park (50.01, -96.91, elevation approx. 260 m) in July 2017. Collections were targeted to several open, sandy clearings and fields that were surrounded by woods. Flowering plants in the areas sampled included spreading dogbane (*Apocynum androsaemifolium* L.; Apocynaceae), white sweet clover (*Melilotus albus* Medik.; Fabaceae), sunflower (*Helianthus* spp.), purple prairie clover (*D. purpurea*), white prairie clover (*Dalea candida* Michx. ex Willd.; Fabaceae), bladder campion (*Silene vulgaris* (Moench) Garcke; Caryophyllaceae) and harebell (*C. rotundifolia*). Bees were net collected by J. Gibbs on 19 August 2017 from Sandilands Provincial Forest in a staging area for all terrain vehicles (49.647, -96.26, elevation approx. 300 m). The site was an open clearing surrounded by woods. Flowering plants included goldenrods (*Solidago* spp.), asters (*Symphotrichum* spp.; Asteraceae), fireweed (*Chamerion angustifolium* (L.) Holub; Onagraceae), and gumweed (*Grindelia squarrosa* (Pursh) Dunal; Asteraceae). Additional net collections were made on 9 July 2018 from the parking lot at the Tillenius Trail, Clematis Wildlife Management Area (50.61, -97.508, elevation approx. 275 m). Flowers included a diverse number of exotic weeds, including white sweet clover (*M. albus*) and bird's-foot trefoil (*Lotus corniculatus* L.; Fabaceae), and native species such as sunflower (*Helianthus* spp.), purple prairie clover (*D. purpurea*), and white prairie clover (*D. candida*).

Specimens are deposited in the Living Prairie Museum entomological collection (LPMEC) and the J.B. Wallis-R.E. Roughley Museum of Entomology (WRME) at the University of Manitoba. Identifications were made using published keys (Schwarz 1926; Timberlake 1943; Grigarick and Stange 1968; Packer *et al.* 2007) and comparison to voucher material at WRME. The novelty of distribution records was assessed using published literature (*e.g.*, Grigarick and Stange 1968; Hurd 1979; Romankova 2004; Sheffield *et al.* 2014), online records (<http://discoverlife.org>; <http://bugguide.net>), and personal communication with C. Sheffield (1 June, 2017) of the Royal Saskatchewan Museum, D. Robson (25 May, 2017) of the Manitoba Museum, and S. Cardinal (25 May, 2017) of the Canadian National Collection of Insects, Arachnids, and Nematodes (CNC).

Results

We recorded five females and six males of *D. p. pudicum* from four sites in southern Manitoba during 2014 to 2017. Two females and one male of *D. simile* were collected from one location in the southeast of the province in 2017. Detailed specimen records are provided below.

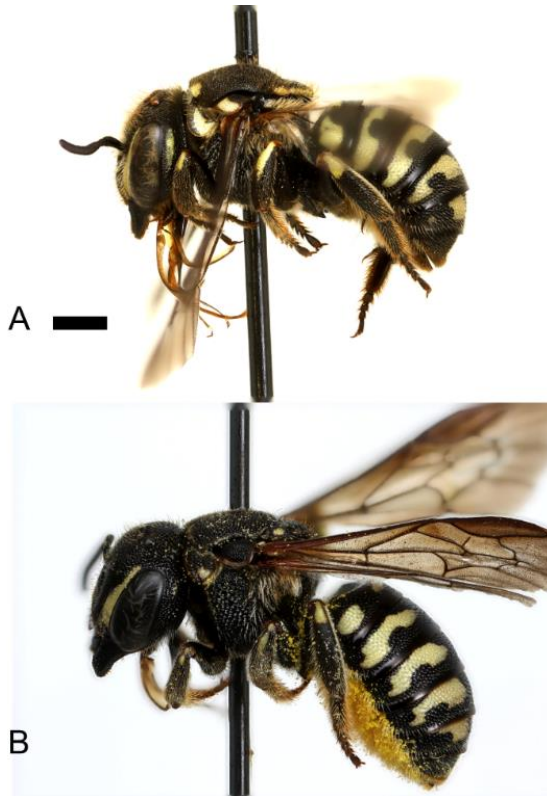


Figure 1. (A) *Dianthidium pudicum pudicum*, female. (B) *Dianthidium simile*, female. Scale bar = 1 mm.

Dianthidium (Dianthidium) pudicum pudicum (Cresson 1879)

(Figs. 1A; 2A; 3A, C)

New provincial records. MANITOBA: *Division No. 1*: Tall Grass Prairie Preserve, 49.155, -96.740, ex. blue bowl trap, 6–8 July, 2017, leg. R. Miller (1 ♀ JBWM); *Division No. 11*: Winnipeg, Rotary Prairie Provincial Park, 49.898, -97.034, ex. *Dalea purpurea* (Fabaceae), 30 July, 2014, leg. S. Semmler (1 ♀ LPMEC; Fig. 1); *Division No. 12*: Birds Hill Provincial Park, 50.013, -96.921, 2 July, 2017, ex. pan trap, leg. J. Gibbs, G.Y. Nozoe (1 ♀ JBWM); Birds Hill Provincial Park, 50.015, -96.916, 2 July, 2017, ex. pan

trap, leg. J. Gibbs, G.Y. Nozoe (1 ♀ JBWM); Birds Hill Provincial Park, 50.015, -96.916, 9 July, 2017, ex. pan trap, leg. J. Gibbs, G.Y. Nozoe (1 ♂ JBWM); Birds Hill Provincial Park, 50.007, -96.910, 9 July 2017, ex. pan trap, leg. J. Gibbs, G.Y. Nozoe (1 ♂ JBWM); Birds Hill Provincial Park, 50.014, -96.917, 9 July, 2017, ex. net, leg. J. Gibbs, G.Y. Nozoe (1 ♂ JBWM); Birds Hill Provincial Park, 50.014, -96.917, 19 July 2017, ex. net, leg. J. Gibbs, G.Y. Nozoe (1 ♂ JBWM); *Division No. 15*: 5 km S of St. Lazare, 50.403, -101.309, ex. blue pan trap, 11 August 2014, leg. M. Olynyk (1 ♂ JBWM; Fig. 2); 5 km S of St. Lazare, 50.403, -101.309, ex. pan trap, 26 June 2015, leg. M. Olynyk (1 ♀ 1 ♂ JBWM).

***Dianthidium (Dianthidium) simile* (Cresson 1864)**

(Figs. 1B; 2B; 3B, D)

New provincial records: MANITOBA: *Division No. 1*: Sandilands Provincial Forest, 49.647, -96.260, ex. *Grindelia* (Asteraceae), 19 August 2017, leg. J. Gibbs (2 ♀♀ 1 ♂ JBWM). An additional male was video recorded mating with one of the above females on a *Grindelia* flower (<https://youtu.be/DvehIs-uKD0>), but escaped collection.



Figure 2. (A) *Dianthidium pudicum pudicum*, male. (B) *Dianthidium simile*, male. Scale bar = 1 mm.

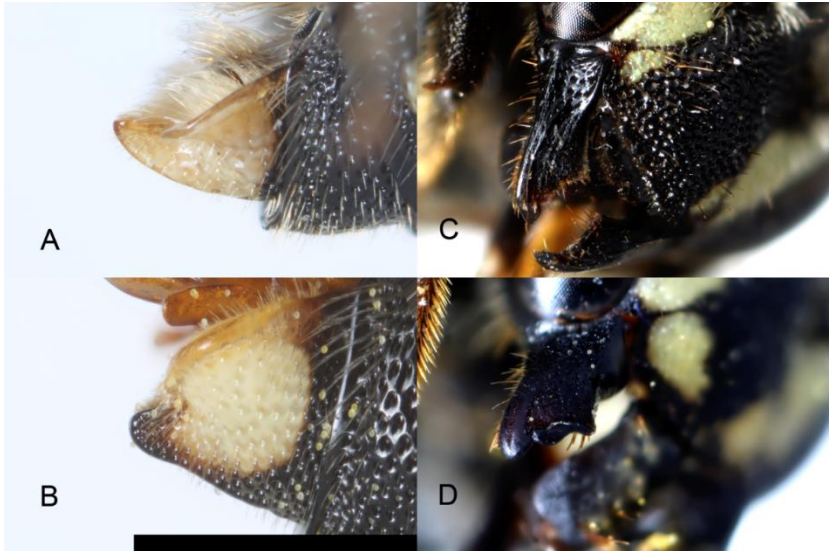


Figure 3. Lateral view of tergum 7 in males of (A) *Dianthidium pudicum pudicum* and (B) *Dianthidium simile*. Comparison of preapical tooth on mandibles of female (C) *Dianthidium pudicum pudicum* and (D) *Dianthidium simile*. Scale bar = 1 mm.

Key to *Dianthidium* in Manitoba

- 1. Fore coxa with apicoventral spine 2
- Fore coxa without apicoventral spine 3

- 2. Face lateral maculation narrow above; mesoscutum anterior maculation small, widely separated from tegula *Dianthidium simile*
- Face lateral maculation not narrow above; mesoscutum anterior to maculation large, narrowly separated from tegula (known from Minnesota and North Dakota) *Dianthidium curvatum*

- 3. Mandible of female with distinct preapical tooth; male T7 with distance between median and lateral lobes half apical width of lateral lobe; both sexes with legs marked extensively with red maculations *Dianthidium concinnum*
- Mandible of female without distinct preapical tooth; male T7 with distance between median and lateral lobes subequal to apical width of lateral lobe; legs of both sexes marked with pale yellow to ivory maculations *Dianthidium pudicum*

Discussion

Dianthidium pudicum pudicum has an extensive range in western Canada, but until recently, no specimens had been reported east of Saskatchewan. Provincial records at the CNC include British Columbia and Alberta (S. Cardinal, *pers. comm.*). The species appears to be common in Saskatchewan, particularly in the southwest (C. Sheffield, *pers. comm.*). There are no specimens at the Manitoba Museum (D. Robson, *pers. comm.*) and the specimens recorded here are the first representatives for the WRME.

Dianthidium simile is an eastern species that reaches its northwestern range limit in eastern Manitoba. The collection reported here is approximately 240 km further north than any previous record (<http://bugguide.net/node/view/212136/bgpape>) and 1000 km further west than the nearest Canadian record in Sudbury, Ontario (Evans, 1896; Romanokova 2003). This gap is not too surprising given the limited sampling effort in the northern Great Lakes Region.

The recent detection of these species may be due to increased sampling effort for pollinators in the province. Few published studies have included extensive surveys of bee fauna in Manitoba, with most occurring in the last 10 years (Patenaude 2007, Robson 2008, Semmler 2015, Olynyk 2017). However, Birds Hill Provincial Park and Sandilands Provincial Forest were repeatedly sampled for bees in the 1970's and 1980's—specimens deposited at JBWM—without collecting any *Dianthidium*. It is somewhat surprising that no specimens of either species have been captured previously. There is not sufficient evidence for a range expansion at this time, but similar patterns suggestive of range extensions have recently been documented for other solitary bee species (Gibbs *et al.* 2014; Zarrillo *et al.* 2016). Note: Following acceptance of the manuscript, three females of *Dianthidium (Dianthidum) concinnum* (Cresson 1872), a new record for Canada, were collected from Spruce Woods Provincial Park. Females have a distinct preapical tooth, procoxa unarmed, and have distinctly red legs. They are deposited in JBWM. The closest known record is from Badlands National Park, South Dakota.

Acknowledgements

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Abstracts

2017 Joint Annual Meeting
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Manitoba

Réunion Conjointe Annuelle
2017
Société d'entomologie du Canada
et
Société d'entomologie du
Manitoba



Fairmont Hotel, Winnipeg, Manitoba,
22-25 October, 2017
Hôtel Fairmont, Winnipeg, Manitoba,
22-25 octobre, 2017



13:00- 17:30 Sunday**Keynote Address****Angela Douglas**

Keynote Speaker: Department of Entomology, Cornell University, Ithaca, New York, USA; aes326@cornell.edu

Bugs within bugs: how microbes promote insect fitness.

Just like other animals, insects harbor a community of microorganisms that support their health and fitness. But insects are special in that their interactions with microbial partners are particularly diverse and well-studied. We can apply our knowledge of insect-microbial interactions for novel strategies to control insect pests and protect beneficial insects, as well as biomedical models for human microbiome research. My presentation will review the diversity of insect-microbial symbioses, emphasizing the ways in which insects benefit from their microbial partners, and provide an overview of our recent research on the gut microbiome in *Drosophila* species and intracellular symbioses in sap-feeding hemipterans. I will explain how perturbation of the gut microbiome can make *Drosophila* fat, and how specific bacteria, including taxa related to human probiotic bacteria, can rescue the lean phenotype, and I will describe how aphids and whiteflies engage in complex metabolic conversations with their symbiotic bacteria, driven by selection for function in the face of genomic decay of the bacterial partners.

Symposium – Highlighting Student Research Across Canada**Megan Colwell¹, Currie, R.W¹, Pernal, S.F.²**

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Epidemiological implications of wax- and airborne honey bee (*Apis mellifera*) viruses and potential treatments.

Honey bee viruses have been studied extensively since their discovery, but much basic work remains to be done. Possible transmission routes, such as surface contamination, have scarcely been studied. Our earlier work showed that honey bee viruses are present, with high prevalence, on wax from dead colonies. Additionally, viruses are introduced to wax via simple worker activity, even when excluding food storage and brood rearing, with evidence for virus transmission through aerosolization. Our current work examines infectivity and stability of wax- and airborne viruses with four experiments: wax wash injection, wax brood rearing, airborne infectivity, and storage and heat treatment. For wax wash injections, pupae were injected with washes of high virus (HV) wax and controls, incubated and sampled for viruses at 48 and 72 h. For wax brood rearing, wax frames from HV and low virus (LV) colonies were inserted into observation hives with mated queens, which were restricted to frames for egg laying. Pupa were sampled at pink- to purple-eyed stages. It was repeated with wax stored for 30 days. For airborne infectivity, HV and LV adult workers were caged and separated by either single mesh (contact cages) or double mesh (air only cages) and LV only baseline controls. Cages were incubated with individual air supplies. For

storage and heat treatment, HV wax was taken and stored at several beekeeper-appropriate temperatures and held at high a temperature to test for declines in virus levels. Viruses in each experiment were quantified by RT-qPCR and compared by treatment.

Ronald Batallas, Maya Evenden

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The basis for cutworm (Lepidoptera: Noctuidae) integrated pest management: understanding crop-pest interaction and moth community structure in prairie agro-ecosystems.

Cutworms (Lepidoptera: Noctuidae) include pest species that affect crops throughout the Canadian Prairies. Although population outbreaks can lead to crop destruction, no tools have been developed to monitor cutworm populations in the Prairie Provinces. To establish an effective monitoring program, it is important to understand cutworm-crop interactions at individual and population levels. The aim of this research is to build the basis for cutworm Integrated Pest Management through investigating larval nutritional ecology and chemical ecology of adult feeding behaviour. We tested the effect of host plant species and plant nutrition on larval performance and feeding preference for two common cutworm pest species. Larval feeding studies provide insight into the potential use of agricultural practices, such as crop rotation and crop fertilization, for management of cutworm populations. The feeding behaviour of adult cutworms, involves responses to volatile cues in the habitat including host plant volatiles, floral compounds and microbial emissions from fermented sugars. To exploit this behaviour and develop a semiochemical-based monitoring tool, we tested various food bait lures that provided volatile cues from different sources, at different release rates and from different dispenser types. The importance of moth physiological state on response to feeding attractant lures was tested using electroantennogram assays. This work has led to the development of a semiochemical-based tool for monitoring multiple cutworm species that also minimizes pollinator bycatch in baited traps. Studying diversity of moths attracted to different food-based semiochemicals will further our knowledge on the diversity of noctuid moths in agroecosystems.

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Effects of extreme temperatures on the survival of the quarantine stored-product pest, *Trogoderma granarium* (khapra beetle), and on its associated bacteria.

Trogoderma granarium is a pest of stored-grain products in Asia and Africa, and a quarantine pest for much of the rest of the world. To evaluate extreme temperatures as a control strategy for this pest, I investigated the effect of low temperatures on the survival and on the microbiome of *T. granarium*. The cold tolerance of *T. granarium*

was assessed by measuring the supercooling points (SCP) of different life stages. The lowest SCP for larvae, $24.3 \pm 0.3^\circ\text{C}$, was obtained for diapausing-acclimated larvae. According to LT₅₀ values, the most cold tolerant stage at 10°C , was the diapausing-acclimated larvae (87 days, CI = 78-97 days). In light of the long exposure time needed to control *T. granarium* even at 20°C , cooling to below 27°C (*i.e.*, below the SCP of eggs) will quickly kill all life stages and may be the best way to control this insect with low temperatures. The microbiome of *T. granarium* seems to be dominated by *Spiroplasma* bacteria. The microbiome was affected by life stage, but an effect of low temperatures was not detected. Further research is necessary to understand the *Spiroplasma-T. granarium* relationship. Future research should also investigate combinations of extreme temperatures with other techniques to shorten the time required for mortality.

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Polarized light and host selection in *Pieris rapae*.

Studies of visual host plant selection by phytophagous insects have focused on spectral characteristics of plants, disregarding polarization information even though sensitivity to polarized light is widespread among insects. Using *Pieris rapae* (Lepidoptera: Pieridae) as a model species, we tested the hypothesis that phytophagous insects respond to polarized light as an essential attribute of the host plant gestalt. We (i) determined the angle and degree of linear polarization (AoP & DoLP) of various plants through photographic polarimetry, (ii) studied the polarization sensitivity of *P. rapae* photoreceptors through electrophysiological recordings and electron microscopy, and (iii) bioassayed the responses of *P. rapae* females to plants, or plant images, that differed in the AoP or DoLP. We found that the DoLP of host and non-host plants varied more markedly than their colour. Moreover, most host plants of *P. rapae* had a relatively low DoLP. Electron microscopy and electrophysiology revealed that *P. rapae* have polarization-sensitive blue, green and red photoreceptors. In bioassays, *P. rapae* females significantly preferred plants, or images of plants, with a low DoLP over to those with a high DoLP. This preference disappeared when we experimentally reduced the DoLP of plants to near 0%. In further experiments, females avoided plants with an AoP of 45 or 135° and a DoLP atypical of a host plant (25%). Our data support the hypothesis that polarized light is an essential attribute of the host plant gestalt that affects host plant selection by female *P. rapae* and possibly other phytophagous insects.

13:30 - 17:30 Monday

Symposium – Small but Complex: The Surprising Nature of an Ectoparasitic Existence

Dale Clayton

Keynote Speaker

Department of Biology, University of Utah, Salt Lake City, Utah, USA;
clayton@biology.utah.edu

Co-adaptive diversification in feather lice: integrating ecology and history.

Co-evolutionary biologists have successfully demonstrated coadaptation of species in response to reciprocal selective forces exerted between those species. In contrast, few studies have tested the influence of coadaptation on diversification (including speciation) of one or both of the interacting groups. Ectoparasites, such as feather lice, are powerful models for studies of co-adaptive diversification because they are unusually tractable for work in both micro- and macro-evolutionary time. I will present recent work from our lab testing the influence of reciprocal selection on the diversification of feather lice (Phthiraptera: Ischnocera), including the experimental evolution of body size, color, and reproductive isolation.

Heather Proctor, Arnika Oddy-van Oploo

Department of Biological Sciences, University of Alberta, Edmonton, AB;
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What do bird mites eat?

Birds host a great diversity of symbiotic mites, some of which are clearly parasitic, harming hosts with their feeding, while others have more ambiguous trophic behaviour. The former include ticks (Ixodida) and blood-feeding species of Mesostigmata, such as nasal mites (Rhinonyssidae) and the infamous nest mites (Dermanyssidae and Ornithonyssidae). Parasitic Prostigmata include chiggers (Trombiculidae, Leeuwenhoeekiidae) and probably also the skin-burrowing Harpirhynchidae and bizarre Cloacaridae. In the Astigmata, members of the tissue-invasive family Hypoderatidae likely feed at the expense of host fitness. But the vast majority of bird-associated Astigmata, the feather mites (Analoidea and Pterolichoidea, ~2500 named species), do not appear to consume living host tissues. Quill-dwelling species feed on feather pith, which may weaken the feathers and potentially result in energy loss for the host, but most of these mites live on the surface of feathers. What do they eat? Some ornithologists assume that feather mites consume feather barbules and class them with feather lice as parasites, but the prevailing view among feather mite biologists is that feather mites are commensals that feed on preen oil plus whatever particles are trapped therein. Despite this disagreement, there has been no concerted effort to document gut contents of feather mites. Here we review what is known of the diets of bird-associated mites and present new data on gut contents observed in slide-mounted specimens representing 94 genera of feather mites from 20 families taken from 197 species of birds from 71 families from North America, South America, China, the Philippines and Australia.

Robbin Lindsay

National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, MB; robbin.lindsay@phac-aspc.gc.ca

The dynamics of vector-borne pathogen transmission cycles: the beauty is in the details.

Definitive evidence that arthropods play a central role in the transmission of pathogens to humans and other animals was first reported in the scientific literature in the latter part of the 1800s. Since the initial descriptions of vector-borne infections, a diverse array of micro-organisms (*e.g.*, bacteria, viruses, protozoans and filarial nematodes) has been shown to be transmissible by arthropods and a wide variety of modes and routes of pathogen transmission have been documented. Most transmission cycles have been elucidated using observations (field studies) of contact processes, genetic studies involving markers, and experimental studies. Effective pathogen transmission is influenced by a myriad of variables some of which are intrinsic to the host, the pathogen, or the vector and interactions between these variables are often critical to the success or failure of pathogen transmission. The goal of this seminar will be to highlight the beauty of the complexity of pathogen transmission cycles and the elegance of interplay between host, pathogen and vectors. Examples will be drawn from flea-, mosquito- and tick-borne pathogens and special emphasis will be placed on several unique aspects of pathogen transmission including: co-feeding or non-systemic infection, the role of vector microbiomes as well as behavioural changes in vectors that may be modulated by pathogens. Where possible, gaps in our understanding of the mechanisms of pathogen transmission will be identified and discussed from a methodological standpoint.

Neil Chilton

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Genetic variation in ticks in Canada and their associated bacteria.

Ticks are important vectors of pathogenic bacteria to humans and domestic animals in North America. Range expansion and increasing abundance of some tick species (*e.g.*, the blacklegged tick, *Ixodes scapularis*) poses an increased threat to human and animal health in Canada. Knowledge of the genetic diversity of ticks and the bacteria they carry is important in our understanding of the ecology and epidemiology of vector-borne disease agents. Population genetic studies on ticks provide valuable information on gene flow and dispersal among fragmented populations. The phylogeography of vectors and their pathogens can also be inferred using population genetic data. The objective of this presentation will be to provide a comparison of the genetic diversity in several tick species (*Dermacentor* and *Ixodes* spp.) that differ in their biology and ecology (*e.g.*, life cycle characteristics, types of hosts used and geographic distribution), and to examine biological significance of the genetic variation in ticks and some of the species of bacteria they carry. The importance of sample size and genetic markers used in population genetic studies of ticks and tick-borne bacteria will also be discussed.

Patricia A. MacKay, Robert J. Lamb

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Are aphids just ectoparasites on really slow moving hosts?

Accepted definitions of the terms parasite and ectoparasite will be used to argue that aphids, like lice, fleas, ticks, and some mites, can be considered ectoparasites but in this case of plants. The concepts of prevalence (proportion of hosts infested) and intensity (mean number of parasites per infested host), as components of abundance (mean number of parasites per host), are used by parasitologists to describe populations of parasites including ectoparasites. These concepts will be used to describe populations of one aphid species, *Uroleucon rudbeckiae*, which has as host a single plant species, *Rudbeckia laciniata*. Evaluating aphid populations by breaking abundance into its components, prevalence and intensity, aids in developing a deeper understanding of population processes. Prevalence, which is much simpler and faster to measure than intensity, is more closely correlated with abundance. Intensity is more important in determining levels of dispersal. Some kinds of predators may be more affected by differences in prevalence, while other predators may be more affected by the level of intensity. Where possible, similarities and differences between the life history and ecology of this aphid and that of groups such as lice, fleas and ticks will be pointed out. The greatest differences appear to be related to the processes of dispersal and predation.

Heritage Lecture

Terry D. Galloway

Department of Entomology, University of Manitoba, Winnipeg, MB;
terry.galloway@umanitoba.ca

A brief history of biting fly research in Manitoba: it really bites.

What is it like for an entomologist to work in a place where the provincial bird is the mosquito, *Aedes vexans*? The Keystone Province is, in fact, ideal for research on many types of biting flies (mosquitoes, black flies, tabanids, and no-see-ums). Its boundaries stretch from the tundra region of the Hudson Bay Lowlands, across vast areas of boreal forest, through a transition of parklands to flat grassland regions, all with rivers, streams and wetlands galore. Teams of early post-WWII researchers swarmed the area around Churchill in almost military precision to learn all they could about reducing the impact of these flies. The Souris River provides intermittent outbreaks during which intensity of black fly attack and damage to livestock have been considerable. Immense numbers of tabanids in southeastern Manitoba led to the innovation of the Manitoba Horse Fly Trap, now employed around the world. A series of expert city entomologists have led a well-designed, regimented mosquito control programme, even as controversy swirled around the application of toxic adulticides and larvicides in urban environments, sometimes in the face of public health emergencies to reduce the threat of mosquito-borne viruses. The Canada Biting Fly Centre was established in the Department of Entomology at the University of Manitoba to coordinate research and

activities related to biting fly research in Canada, and to conduct contract research on biting flies. It all sounds like heaven to me.

8:30- 11:45 Tuesday

Symposium – Impacts of Forest Management on Insect Diversity

Keith Summerville

Keynote Speaker

Drake University, Des Moines, Iowa, USA; keith.summerville@drake.edu

Synthesizing results from landscape-scale, experimental forestry studies to understand ecological resilience and disturbance: a case study using Lepidoptera (and other taxa).

Insects are important components of forest ecosystems. They affect tree growth and influence nutrient cycling, provide food for higher trophic levels, and can serve as pollinators. Forest insects are also impacted by timber harvest, with responses varying from positive to highly negative depending on the taxa in question, the spatial scale of inquiry, and severity of the harvest regime. Landscape-scale, multiyear experimental systems such as EMEND, MOFEP, and HEE have greatly advanced our understanding of insect community resistance and resilience to harvest disturbance. Using the Lepidoptera as a focal taxa, I compared the results from these long-term studies to test hypotheses regarding the severity of timber harvest and the resilience of moth communities. Species composition appeared much more resilient to timber harvest under shelterwood management, recovering to the near original condition in as few as three years post treatment. Communities in patch cut or clear cut stands were slower to recover, and appeared to develop novel species assemblages. Year effects were as important in influencing species assemblages as the any harvest treatment, suggesting an important role for stochastic effects in creating community structure. Together, these results demonstrate that lepidopteran communities respond immediately to logging due to changes in host plant availability, but may also be impacted many years subsequent due to stochastic year effects and seral changes in forest structure and composition. New studies designed to synthesize the disturbance ecology of forestry with metacommunity dynamics occurring among harvest concessions are needed to better predict community structure over time.

Greg Pohl¹, David Langor¹, Jan Klimaszewski²

¹Natural Resources Canada, Canadian Forest Service, Edmonton, AB; ²Ressources naturelles Canada, Service canadien des forêts, Centre de foresterie des Laurentides, Sainte-Foy, QC; greg.pohl@canada.ca

Biodiversity research with rove beetles (Coleoptera: Staphylinidae) in western Canadian forests.

We review the state of taxonomic and biological knowledge of rove beetles in Canada. Spatial and temporal distribution patterns, and the effects of anthropogenic and natural disturbance are explored, with an emphasis on western boreal and cordilleran forests. We also examine the use of rove beetles as indicators of ecosystem health, and as

surrogates for other groups. We identify key gaps in our current knowledge, and make recommendations for conservation of rove beetles in managed forests.

Sandy Smith, J. Malcolm, E. Barkley, J. Dennis, L. Timms, N. Islam, M.L. Seehausen, M.I. Bellocq

Faculty of Forestry, University of Toronto, Toronto, ON; s.smith.a@utoronto.ca

Hidden jewels in Canada's eastern boreal forest: shedding light on the diversity of our parasitic Hymenoptera.

Parasitic wasps are an extraordinarily large insect group, one playing a key role in terrestrial ecosystems through their regulation of insect populations. Most are rare and particularly vulnerable to extinction, yet to date this group has been largely neglected in conservation studies. To understand the distribution patterns and habitat requirements of parasitic wasps in Canada's eastern boreal forest, we analyzed wasp assemblages from different forest strata and substrates. Forest sites (18) were selected across the northern clay belt of Ontario, ranging in age from 35-130 years old. At each site, flying insects were collected from two different canopy heights using aerial flight intercept Malaise traps. Microhabitat substrates were investigated by collecting insects from dead wood (of different tree species, stage of decay, and wood posture), moss, and soil over a 3-year period. Here, we identify rare and common taxa (subfamilies and genera) and provide new information on the use of forest microhabitats (canopy, understory, substrate) by selected taxa. Because many parasitoids are host-specific and habitat specialists, the predicted differences in composition, richness, and abundance of parasitoid assemblages we observed in our study can be used to inform future conservation.

David MacLean

Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB; macleand@unb.ca

Benefits of mixedwood management: reduced spruce budworm impacts in Acadian spruce-fir hardwood forests.

The Acadian Forest in Atlantic Canada and Maine consists of a diverse mix of northern hardwoods with boreal conifer tree species. Periodic spruce budworm (*Choristoneura fumiferana* (Clem.)) outbreaks are the dominant natural disturbance in the region, with major stand-killing outbreaks recurring every 35-40 years. Balsam fir (*Abies balsamea*) and spruce (*Picea*) in stands and landscapes with higher hardwood content have been repeatedly observed to have lower susceptibility and vulnerability during spruce budworm outbreaks. Hardwood content >40% reduces budworm-caused defoliation of balsam fir, cumulative fir mortality decreases with increasing hardwoods, and budworm-caused growth reduction of fir decreased when surrounding landscape hardwood content was >50%. The hardwood "protective" effects have been attributed to higher parasitism rates of budworm and/or greater larval dispersal losses with higher hardwood content. We are testing these hypotheses in a spruce budworm outbreak that began in 2013 near Amqui, QC. Twenty-seven plots representing a gradient of fir-hardwood stands were sampled for defoliation, budworm population at

six life stages, parasitism rates of budworm, and dispersal losses of first and second instar larvae. Results have shown that fir defoliation and budworm population level were significantly negatively related to hardwood content. Optimum hardwood level for management depends on severity of budworm attack: below 45% defoliation (5 year average), fir volume lost to increased hardwood growing space exceeded the amount of volume protected, but as defoliation increased above 45%, optimal hardwood levels increased. At severe levels of defoliation (>75%) optimal hardwood content was approximately 50% of initial standing volume. Results suggest that mixed stand management can reduce balsam fir volume losses in areas with frequent severe spruce budworm outbreaks.

Richard Westwood, Andrew Park

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Does conversion of endemic jack pine to commercial red pine plantations in central Canada lead to declines in the diversity of plants and Lepidoptera on a landscape level?

In Manitoba and northwestern Ontario, jack pine (*Pinus banksiana*) has been a key commercial forestry species for the last 100 years. Over the past 50 years red pine (*Pinus resinosa*) has been increasingly used as a plantation species in areas that naturally support fire origin Jack pine forests. The purpose of our research was to determine if native jack pine forests (JPF) have greater plant and arthropod diversity in comparison to red pine plantations (RPP). We hypothesized that RPP would be less than JPF which may lead to declines in species and community richness in comparison with traditional Jack pine ecosystems at local and perhaps landscape levels. We used a chronosequence approach where replicated RPP and JPF stands were selected in two age classes to examine plant and moth diversity. Results showed significant differences in the basic physical and biological characteristics of the two forest types which were linked to lower plant diversity in RPP and increased moth diversity in JPF. Over 300 species of moths were recorded in the study and a functional trait analysis approach was used to identify moth species associations between plants within forest types to determine if vegetation and physical variables patterns matched the moth diversity. It is recommended that where RPP proliferate in JPF efforts should be made to maintain habitat diversity by ensuring that all age classes of Jack pine forest are included in the landscape mosaic to conserve and protect those species that have co-evolved with Jack pine since the last ice age.

13:30- 16:45 Tuesday

Symposium – Pollination in a Climate of Change

Nigel Raine

Keynote Speaker

School of Environmental Sciences, University of Guelph, Guelph, ON;
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Pollinators and pollination under pressure: the impacts of pesticide exposure on wild bees as a case study.

Pollinators are essential to agricultural production (particularly fruit, vegetable and nut crops) and maintaining the health and diversity of wild plant communities. There is well established evidence showing declines in pollinators around the world with associated evidence of reductions in crop pollination services leading to reduced yield (pollination deficits). This raises concerns for agricultural production and maintenance of biodiversity around the world. Multiple environmental stressors are driving pollinator declines, including land use change, climate change, agrochemical usage, pests & pathogens, and management practices, and interactions between these stress factors are likely to be important. Conserving pollinators, and the essential ecosystem services they provide, requires us to understand and mitigate the impacts of these multiple stressors in the environment. There has been a surge in research into the potential impacts of pesticides on pollinators, particularly systemic neonicotinoid insecticides, over the last decade. Recent studies have revealed the extent to which field- realistic neonicotinoid exposure can lead to significant sublethal impacts on individual bumblebee behaviour (*e.g.*, reduced queen colony founding success and impaired worker learning and foraging), colony function (*e.g.*, effects on growth rates and forager recruitment), and the critical ecosystem services they provide to crops and wild plants. Taken together these effects could have widespread implications for the stability of wild pollinator populations, sustainable production of pollinator limited crops, and maintaining wild plant biodiversity. Considering these studies reporting insecticide impacts on non-*Apis* bees into the wider context, particularly alongside divergent results from honey bee field trials, has important ramifications for pesticide use policies

Anne Worley, Dawn Wood

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Can small generalized visitors save the day when more specialized pollinators are scarce? Floral visitor diversity and reproduction in the perennial herb, *Polemonium brandegeei*.

Many plant species have diverse floral visitors, even when their flowers have traits associated with specific group(s) of pollinators. Visitors may range from mutualist pollinators to floral antagonists that consume rewards without pollinating. The perennial herb, *Polemonium brandegeei*, has floral features associated with both hummingbirds and hawkmoths. Previous work in experimental populations showed

that these syndrome pollinators exerted contrasting selection on floral traits. However, the open flowers also allow pollen feeding by non-syndrome solitary bees and syrphid flies, and their influence on reproduction was unexplored. We conducted a two-year study in a natural population to compare the role of syndrome and non-syndrome visitors. Visits from hawkmoths and hummingbirds were rare, but they visited multiple plants per bout. Smaller solitary bees and syrphid flies were common, but visited few plants per bout. We applied three treatments to understand better the role of large and small visitors. First, excluding large visitors with broad mesh tents did not affect pollen deposition, and only reduced seed set in one year. Second, plants with emasculated flowers received less pollen but had similar seed set to plants with intact flowers, indicating substantial deposition of incompatible self-pollen. Third, supplemental pollen indicated that seed production was not limited by pollen receipt, although seed herbivory reduced our sample size. Overall, our results indicated that small, non-syndrome visitors may contribute substantially to female fitness in some years and thus affect selection on floral traits. Ongoing work is focused on male fitness (pollen removal) and seed quality.

Kyle Bobiwash, Elizabeth Elle

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Improving farm management for pollinators in highbush blueberry.

Beneficial insect biodiversity in British Columbia highbush blueberry fields is generally low; however, the value of beneficial insects can be significant to the crop. The quality of a blueberry harvest relies heavily on both pollinator diversity and abundance to maximize production. A variety of recommended agricultural practices in the crop are recommended to farmers, however, many of these may affect local insect biodiversity. Identifying elements and characteristics within the farm landscapes that drive diversity is important in developing effective farm management strategies. Understanding the needs of pollinators and other beneficial in the landscape can allow farmers to plan management activities to optimize the available local ecosystem service delivery. Through analyzing trends in diversity data, we can enhance our ability to predict the impact of agricultural practices or management strategies on ecosystem service delivery. Farmer and consultant input is needed to develop tools that will allow for the inclusion of the most recent research in landscape management. Through increased partnerships with all stakeholders biodiversity research can better meet the needs and capacity of farmers to improve their farm land management for biodiversity and crop production.

Jason Gibbs

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Integrated crop pollination: lessons learned from Project ICP

The Integrated Crop Pollination (ICP) Project was a 5-year multi-institutional USDA-funded project studying pollinators and pollination service in specialty crops in the

United States and Canada (BC) (www.projecticp.org). ICP is the combined use of multiple pollinator species, habitat augmentation, and crop management practices to provide reliable and economical pollination of crops. Based on four field seasons in Michigan, USA, I highlight lessons learned from research in highbush blueberry and sour cherry in Michigan that include: 1) how to waste resources on alternative managed bees, 2) how to fail at establishing pollinator habitat, 3) how to get misleading results on pollinator communities; and 4) how to kill too many bees.

Rob Currie¹, Alexandra Sebastien², Renata Borba³, Leslie Eccles⁴, Leonard Foster², Pierre Giovenazzo⁴, Heather Higo², Shelley Hoover⁵, Stephen Pernal⁶, Amro Zayed⁷, Michael Peirson⁶

¹Department of Entomology, University of Manitoba; ²University of British Columbia, Vancouver, BC, Canada; ³Ontario Beekeepers' Association, Guelph, BC; ⁴Université Laval, Québec City, QC; Alberta Agriculture and Forestry, Lethbridge, AB;

⁶Agriculture and Agri-Food Canada, Beaverlodge, AB; ⁷York University, Toronto, ON; Rob.Currie@UManitoba.ca

Honey bee colony loss. What are the causes and what can be done about it?

Honey bees, *Apis mellifera*, have been experiencing high levels of annual colony loss on a regular basis over the past decade resulting in significant economic impacts on bee producers and the crops they pollinate. While speculation related to the causes of colony loss originally centered around the idea that there was a single mysterious cause (CCD), we now know that multiple stressors are interacting, sometimes in unpredictable ways to cause problems for this critically important crop pollinator. This talk will focus on the impact on two of the major factors related to bee mortality, parasites and pathogens. Exciting progress is being made on high and low tech solutions to help mitigate these losses and some of these research innovations include using molecular and proteomic markers as well as conventional approaches to breed bees for resistance to parasites and pathogens. Managing viruses through more effective management of their primary vector, the varroa mite and using RNAi to control viruses also can be effective in helping beekeepers mitigate losses from some of the more critical stressors in the system.

8:30- 12:15 Wednesday

Symposium - Small but Numerous: Towards an Understanding of the Dynamics of Insect Populations

Anthony Ives

Keynote Speaker

Department of Integrative Biology, University of Wisconsin-Madison, Madison, Wisconsin, USA; arives@wisc.edu

The ecological and evolutionary dynamics of pea aphids and their natural enemies.

Environmental changes, such as landscape disturbance and global warming, may alter the strength of interactions among species, leading to changes in population dynamics - how population abundances fluctuate through time and space. Furthermore, these interactions may lead to rapid evolution of one or more of the interacting species, and rapid evolution can in turn alter the interactions between them. Using pea aphids and their natural enemies, I will give examples of how a changing environment can affect the ecological and evolutionary dynamics of predator-prey systems. These examples take advantage of bacterial symbionts that confer ecologically and evolutionarily advantageous traits on their aphid hosts, such as resistance to insect parasitoids.

Rob Johns^{1,2}, L. Flaherty^{2,3}, D. Carleton^{2,4}, S. Edwards², A. Morrison^{2,5}, E. Owens^{2,5}

¹Natural Resources Canada, Canadian Forest Service - Atlantic Forestry Centre, Fredericton, NB; ²Population Ecology Group, Faculty of Forestry and Environmental Management, University of New Brunswick, Fredericton, NB; ³Department of Biological Sciences, MacEwan University, Edmonton, AB; ⁴New Brunswick Department of Natural Resources, Fredericton, NB; ⁵Forest Protection Limited, NB; rob.johns@canada.ca

Population studies of tree-defoliating insects in Canada: a century in review.

My talk will provide a broad sketch of the past century of population ecology research on outbreak-prone insect defoliators in Canadian forests. Since broad-scale surveys began around the 1930s, there have been at least 106 insect defoliators reported to outbreak, most of which are native moths, sawflies, or beetles. Population ecologists have used various empirical and analytical approaches to studying these species, each of which provides a different flavor of insight. For instance, studies comparing life-history traits of outbreak vs. non-outbreak species have shown us that outbreak prone have, among other traits, a tendency towards egg clustering and aggregative larval feeding. Time series studies data that proxy long-term trends in population densities over the landscape have revealed strong evidence for both regular periodicity and spatial synchrony of outbreaks for most major species. Life-table studies, which detail the demographics of fluctuating populations, have highlighted the key role natural enemies (often parasitoids) play in driving outbreak collapse. Experimental approaches have also been essential for testing or developing more specific hypotheses through isolating the relative contributions of bottom-up (host plants) and top-down (natural enemies) factors in shaping defoliator distribution and success. Using a few key case studies, I will discuss some of the interplay between these approaches and attempt to illustrate how they collectively promote our understanding of insect outbreaks. I will conclude with some brief discussion of the many key knowledge gaps that remain and potentially fruitful avenues for future research

Meghan Vankosky, Ross Weiss, Owen Olfert

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Using the past to predict the future: the history, implications, and applications of the Saskatchewan grasshopper survey.

The value of monitoring insect pest populations and understanding the factors that contribute to pest outbreaks was recognized in the Prairies in 1919. Population and distribution data for some insect pests of field crops in the Prairies have been recorded for upwards of 100 years and is ongoing. Insect surveys are primarily conducted for the purposes of determining pest distribution and predicting yearly pest outbreaks. The grasshopper survey, developed in Saskatchewan is one example. Here, we illustrate the history of the grasshopper survey, and discuss its implications and applications. Specifically, the grasshopper survey provides template methodology for surveying other field crop pests and the long-term datasets generated by this survey play an important role in developing grasshopper forecasts and predictive bioclimatic inferential models.

Jens Roland¹, Steve Matter²

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Extreme weather events drive alpine butterfly population dynamics.

Butterflies serve as one of the best examples of bio-geographical range-shifts due to climate change. The mechanisms by which weather and climate alter butterfly dynamics are, however, often lacking. We identify extreme weather events, especially in early winter as having the greatest effect on annual population change (Rt) of alpine *Parnassius smintheus* butterflies in the Rocky Mountains of Alberta. We use novel techniques of tree-based regression (random Forests and recursive partitioning), combined with linear mixed-effects models, to identify weather variables that best explain annual rates of population change. Based on 21 years of population data from 21 sub-populations, we found that extreme cold, and extreme warm temperatures in November are associated with dramatic population declines, particularly in years with little or no snow. Weather at any other time of year bears little relation to annual population change. Results imply that over-wintering eggs are particularly susceptible to temperature extremes in early winter, and that snow cover at this time of year is critical for ameliorating the effects of such extremes.

Robert J. Lamb

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Population variability: is it a species trait adapted to environmental conditions?

As data accumulate on population variability, using the metric PV, relationships are emerging. On the one hand, temporal population variability often differs among species living in the same habitat. On the other hand, a species living in different habitats often shows the same population variability in all of them, although average abundance may differ among habitats. Furthermore, closely related species living in the same habitat have more similar population variability than unrelated species. This is true even when

no relationships can be detected in the timing of peaks and valleys in their abundance. Finally, introduced species exhibit higher levels of population variability than native ones, and population variability declines with the time that a species is present in a new habitat. All of these patterns are consistent with the hypothesis that population variability is a species trait resulting from adaptation, not simply an immediate population response to year to year changes in the environment. Apparently, adaptation is occurring in the direction of a reduced level of population variability. The nature of the selection process that reduces population variation, and the fitness benefits that accrue, remain to be explored.

Alejandro Costamagna

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Landscape ecology: implications for the populations of insect pests of crops.

Landscape-scale processes mediate the interactions between pests and their natural enemies in agroecosystems. Processes affected include field colonization, movement and aggregative responses and overwintering by insect populations. Early landscape-scale studies typically showed that the proportion of natural and semi-natural habitats was associated with higher predator abundance, diversity and pest control services (e.g., pest suppression and parasitism). However, more recent studies have found varied patterns of association between natural and semi-natural habitats and pests, suggesting that system specific studies are needed to understand the role of different habitats in the landscape ecology of pests and their natural enemies. Here I present initial results of three novel systems studied in the Canadian prairies: 1) the soybean aphid, *Aphis glycines* and generalist predators, 2) the cereal leaf beetle, *Oulema melanopus*, and its parasitoid, *Tetrastichus julis*, and 3) the flea beetles, *Phyllotreta striolata* and *P. cruciferae*, which illustrate a diversity of responses to agricultural landscape complexity.

9:30- 12:15 Wednesday

Symposium - Molecular Mechanisms Underlying Insect Diapause and Cold Tolerance

Michel Cusson^{1,3}, Marcelo Brandão², Catherine Béliveau¹, Brian Boyle³, Daniel Doucet⁴, Fayuan Wen⁴, Lisa Lumley⁵, Felix Sperling⁶, Nikoleta Juretic⁷, Ken Dewar⁷, Roger C. Levesque³

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Molecular and endocrine correlates of early-instar diapause in the spruce budworm.

The spruce budworm (*Choristoneura fumiferana*) is a univoltine species that completes diapause as 2nd- instar larvae. Although this diapause is generally considered obligatory, neonate larvae exposed to long day conditions often skip diapause, a feature that enabled the development of a diapause-free budworm strain by Harvey (1957). Little is known about the factors responsible for diapause induction in this and other species that enter diapause as early-instar larvae. To begin exploring the molecular correlates of diapause induction in such insects, we developed a spruce budworm transcriptome and used it as reference to examine differential gene expression between individuals of the diapause and diapause-free strains. For transcriptomic analysis (RNA-seq and qPCR), RNA was collected from eggs, L1s and L2s of diapause and non-diapause insects, and corresponding cDNAs were sequenced (Illumina HiSeq). Differential gene expression analysis first revealed distinct overall patterns during the egg stage, suggesting that diapause is induced at this stage. Several genes involved in the juvenile hormone (JH) and insulin signaling pathways showed differential expression in L1s and L2s, pointing to their possible role in diapause induction in this species. The precise role of these pathways in diapause induction is currently being experimentally assessed.

Pier Jr Morin

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Decoding the role of non-coding RNAs in insect cold hardiness.

While our molecular understanding of cold adaptation has significantly improved in recent years, much remains to be done to fully comprehend life at low temperatures and to translate this knowledge into practical applications. Insect overwintering is associated with a plethora of molecular changes and microRNAs (miRNAs), small non-coding RNAs that are well-characterized for their impact on protein expression, are differentially expressed in select insect models. Nevertheless, information regarding miRNA expression and function during cold response in insects is sparse. Our work thus aims at better understanding the roles played by non-coding RNAs via amplification and quantification of these molecules in cold-exposed insects including the goldenrod gall fly *Eurosta solidaginis* and the Colorado potato beetle *Leptinotarsa decemlineata*. Whether via the quantification of cold-associated miRNA signatures in cold-hardy insects using high-throughput sequencing approaches or through the assessment of functional consequences that result from such changes at low temperatures using bioinformatics- or RNAi-based methods, this talk will highlight the current state of knowledge associated with small non-coding RNAs in cold-hardy insects. Additional strategies to evaluate the molecular alterations, beyond miRNA modulation, observed following cold exposure in the insect pest *L. decemlineata* will also be presented. Overall, characterization of cold-induced signatures of non-coding RNAs could yield crucial information on how natural models of cold adaptation cope with temperature stress and how this strategy could have applications in fields as diverse as organ preservation and pest management.

Julia Bowsher

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Low temperature stress in the alfalfa leafcutting bee, *Megachile rotundata*.

In insects, prolonged exposure to unseasonably low temperatures can lead to detrimental physiological effects known as chill injury. During low temperature exposure, membrane phase changes are hypothesized to lead collapses in ion gradients, metabolic imbalance and oxidative stress. RNA-seq has provided support for these responses at the level of gene expression in the alfalfa leafcutting bee, *Megachile rotundata*, but they are characterized by variable transcriptional responses in different life stages. We assessed oxidative stress in low-temperature-stressed *M. rotundata* in two different life stages by comparing chill injury-inducing static thermal regimes (STR) with protective fluctuating thermal regimes (FTR). We measured the expression of several transcripts with known antioxidant functions during extended prepupal overwintering as well as total antioxidant capacity and lipid peroxidation during both extended overwintering and low temperature stress during pupal development. Real-time PCR showed differential expression of the antioxidant glutathione peroxidase and several transcripts with known antioxidant function including vitellogenin, apolipoprotein D, glutathione S-transferase, and nuclear protein 1, but mostly transient differences in the expression of other enzymatic antioxidants. Interestingly, *M. rotundata* did not vary in its ability to respond to an induced oxidative stress and measurements of lipid peroxidation showed no differences between treatments. These results indicate oxidative damage is not a factor in FTR responses to chill injury in *M. rotundata*.

Brent Sinclair

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Five strategies for effective estimates of insect cold tolerance and detection of diapause.

Cold winters are impressed on the psyche in Canada, which makes will it survive winter an obvious first question about any new invader or pest. Characterising overwintering biology is not only fun, but also fundamental to understanding the population dynamics of insects, and relatively easy to do right. I will summarise some basic lab tools for measuring cold tolerance of, and detecting diapause in, insects and arthropods, and highlight five important considerations when approaching overwintering biology: 1) *Give the insect a break*: giving the insect optimal conditions to develop its innate cold hardiness and enter diapause will give the most conservative (and realistic) estimates of cold tolerance. 2) *Figure out what kills them*: an important first step is determining if an insect is killed by freezing, survives freezing, or is killed by cold at temperatures where ice hasn't formed I will discuss how to distinguish these strategies, and what they mean for subsequent measurements. 3) *Time and temperature matter*: low temperature mortality is usually a complex interplay between the duration and intensity of low temperature exposure, while disentangling temperature effects is essential for determining if an insect is in diapause. 4) *See it from the insect's point of*

view: the context of an insect's overwintering microhabitat might change the low temperature environment and the cues it uses to enter and exit diapause; by considering this, you can design experiments that characterize overwintering in the most appropriate context. 5) *It's not always just about the cold*: don't neglect water balance and energy drain when considering insect overwintering potential!

Daniel Doucet¹, Catherine Béliveau², Brian Boyle³, Jérôme Laroche³, Ken Dewar⁴, Nikolaleta Juretic⁴, Jessica Wasserscheid⁴, Lisa Lumley⁵, Felix Sperling⁶, Roger C. Levesque³, Michel Cusson^{2,3}

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⁵Royal Alberta Museum, Edmonton, AB; ⁶Department of Biological Sciences, University of Alberta, Edmonton, AB⁶

The spruce budworm antifreeze protein gene family: structural analysis using the recently sequenced genome.

The spruce budworm (*Choristoneura fumiferana*), one of the most serious pests of conifers in the North American boreal forest, is well known for its ability to withstand the frigid temperatures of the Canadian winter as diapausing second-instar larvae. How it achieves this feat has long piqued the curiosity of scientists, and previous work has helped shed some light on the processes involved. To help further characterize the various genes and proteins involved in this adaptation, we undertook the sequencing, assembly and analysis of the budworm genome. To sequence and assemble the *C. fumiferana* genome, we used a hybrid NGS strategy, including different sequencing technologies (Roche 454, Illumina and PacBio), different assemblers (Newbler and Celera) and different types of starting material (DNA from a single male pupa, DNA pooled from several males and BAC clones). Analyses focused on selected groups of genes, namely those of the anti-freeze protein (AFP) family. Several new AFP isoforms which were not previously isolated through cDNA cloning were identified in the assembled contigs. While two AFP genes were known to exist as tandem repeats in a previous study, we confirm that at least three AFPs are arranged in this fashion. Further insights on how sbw AFPs arose and evolved will be gained through comparisons of AFP-bearing genomic regions with those of other *Choristoneura* congeners currently being sequenced.

**9:30- 12:30 Wednesday
Symposium**

Biological Survey of Canada

Canada 150: Canada's insect diversity in expected and unexpected places.

Sam Droege

Keynote Speaker

Patuxent Wildlife Research Center, United States Geological Survey, Laurel, Maryland, USA; sdroege@USGS.gov

Successful citizen sciencing: what works and what doesn't.

Budgets have their limits. Most of us make do, but there are times, particularly when looking for inventory and monitoring data for insects, that enlisting the aid of the unpaid is the only way we can see our way to collecting sufficient information. Volunteers are interested and available for helping, but their service is based on different criteria than those folks who get paychecks. We look at diverse examples of successful projects from online data entry of bumble bee labels, counting crickets, BioBlitzs, setting traps for bees, and several vertebrate programs distilling and refining the aspects that make them successful and contrast that with the projects that never quite got off the ground. Hint: Much of the causal agents of success are more about your touchy feely qualities than your statistical ones.

Jason Gibbs

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Resolving taxonomic impediments in a nightmare bee genus, *Lasioglossum* (Hymenoptera: Halictidae). Documenting the sweat bees of the genus *Lasioglossum* (Hymenoptera: Halictidae) in Canada: current progress and outstanding problems.

Lasioglossum (Hymenoptera: Halictidae) is the most species rich genus of bee globally. *Lasioglossum* also displays more diversity in social behaviours than any comparable taxon, making it an ideal candidate for studies of social evolution. Unfortunately, *Lasioglossum* are among the most challenging bees to identify to species. It is represented in Canada by more than 100 species, which typically comprise the bulk of native bee collections in biodiversity surveys. Despite recent taxonomic revisions, *Lasioglossum* remains one of the primary taxonomic impediments to studies of Canadian bees. I discuss the progress that has been made to date to resolve the taxonomy of the genus, recent additions to the Canadian fauna, challenges associated with DNA barcoding *Lasioglossum* bees, and outstanding problems that require additional study.

Terry D. Galloway

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A survey for lice (Phthiraptera) infesting birds and mammals in Manitoba, Canada.

In a Biological Survey of Canada Green Paper, Galloway and Danks (1991) identified two major gaps in the ectoparasite fauna in Canada. Large proportions of the chewing lice and feather mites expected to occur were unrecorded. Recommendations were advanced for entomologists to undertake co-operative efforts with ornithologists and mammalogists to address these gaps. In 1994, the Manitoba Wildlife Rehabilitation Organization opened their new wildlife hospital at the Faculty of Agricultural and Food Sciences Glenlea Research Farm south of the University of Manitoba. The director at the time, Brian Ratcliff, was open to collaboration with the author to provide casualties from the hospital for examination and collection of their ectoparasites. Since then, quantitative data on ectoparasites (~1,000,000 specimens) have been collected from >12,000 animals of 287 species (242 species of birds; 45 species of mammals), from at least 323 locations in the province. There were few published records for lice in Manitoba prior to this survey: chewing lice 31 species infesting birds, 1 species infesting mammals; sucking lice 3 species. The current estimates for taxa of lice collected in the survey are Laemobothriidae 4, Menoponidae 83; Ricinidae 13; Philopteridae 150; Trichodectidae 15; Enderleinellidae 4; Polyplacidae 3; Haematopinidae 1; Hoplopleuridae 6; Linognathidae 6; Pediculidae 1; Pthiridae 1, for a total of 286 species and subspecies, with perhaps more than 70 undescribed species. The positive and negative aspects of acquiring salvaged wildlife for the study of ectoparasites will be discussed.

Jennifer Heron¹, Cory Sheffield²

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Southern British Columbia – summary of the conservation status and diversity of bees, with new records.

British Columbia, especially the southern areas, is Canada's hot spot for bee diversity, with estimates ranging from 450 species in the province, to upwards of 600 species - almost 75% of that known for Canada. Our recent efforts to document the bee fauna of the province has resulted in a species list documenting the patterns of diversity based within ecozones, with several new important records. These efforts have also allowed us to complete the first conservation assessment of British Columbia's bees. These topics will be discussed. We also make note of some recent records, and discuss other interesting species.

Joe Shorthouse

Department of Biology, Laurentian University, Sudbury, ON

Cynipid galls of the wild roses of Waterton Lakes National Park.

Waterton Lakes National Park located in southwestern Alberta, is a biodiversity hot spot for arthropods. Eleven species of cynipids and their galls are found on the three

species of wild roses in the park and although Waterton is the smallest of the Rocky Mountain Parks, it has a larger concentration of species of cynipids than anywhere else in Canada. The history and significance of this assemblage and its role in the distribution of cynipids elsewhere in Canada will be discussed.

8:30- 12:15 Monday

President's Prize: Student Competition Oral Presentations: Agriculture

Shelby Dufton¹, Jennifer Otani², Kevin Floate³, Robert Laird¹

¹University of Lethbridge, Lethbridge, AB; ²Agriculture and Agri-food Canada, Beaverlodge, AB; ³Agriculture and Agri-food Canada, Lethbridge, AB; shelby.dufton@uleth.ca

Effects of crop rotation and canopy cover on orange wheat blossom midge (*Sitodiplosis mosellana*) and assemblages of ground beetles (Coleoptera: Carabidae) in the Peace River Region.

Wheat midge *Sitodiplosis mosellana* Géhin (Diptera: Cecidomyiidae) is an invasive and economic pest in wheat (*Triticum* spp.) that recently established in the Peace River region in 2011. During an outbreak in Saskatchewan in 1983, yield reductions resulted in an estimated loss of \$65 million to the industry. One prominent group of natural enemies of this pest are ground beetles (Coleoptera: Carabidae). This will be the first study to provide season-long community data on carabid communities in this region. A field plot experiment was seeded in Beaverlodge, AB to assess how plant species and seeding rates affect canopy and investigate its relationship to wheat midge infestations and carabid assemblages. The field experiment consisted of 16 paired treatments organized into four replicates. Treatments included two wheat varieties (*Triticum aestivum* cv. AC Stettler and CDC Utmost), canola (*Brassica napus* cv. Invigor L120), peas (*Pisum sativum* cv. CDC Meadow) and lambsquarters (*Chenopodium album* L.). Seeding rates were manipulated in both wheat and canola treatments. Weekly pitfall trap collections (May-August 2016) were used to evaluate carabid communities. In total, 8,200 beetles were collected and 57.2% of these were Carabidae. The three dominant carabid species seen in the 2016 sample were *Poecilus lucublandus*, *Amara thoracica*, and *Carabus taedatus*. The greatest species richness was seen in the highest seeding rate of wheat (cv. CDC Utmost at 400 seeds/m²) and the lowest was seen in peas (cv. CDC Meadow at 100 seeds/m²). This study will yield a better understanding of interactions between *S. mosellana* and its predators.

Alexandre Loureiro, Christopher Cutler, Vilis Nams, Scott White
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Diversity and dispersal of ground beetles (Coleoptera: Carabidae) within commercial lowbush blueberry fields.

Carabidae can be important pest control agents in many agricultural systems. In laboratory experiments, we showed that *Pterostichus melanarius* and *Poecilus lucublandus* did not feed on common lowbush blueberry weed seeds. We also did two field experiments that explored different aspects of Carabidae ecology. In the first,

which is about the diversity and abundance distribution of Carabidae in lowbush blueberry, we found that carabid abundance increases linearly towards the field center, and that carabid diversity has no linear relationship with distance from field edge. In the second, we investigated *Harpalus rufipes* dispersal by measuring how far individuals may move over time. By taking into account both probability of capture and numbers captured, we estimate most of the beetles traveled between 20-50 m after 53 hours.

Christopher Andrews¹, Chris Cutler¹, Steve. Javorek²

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²Agriculture and Agri-Food Canada, Kentville Research and Development Centre, Kentville, NS; crandrews@dal.ca

The effects of landscape character on bumble bee colonies in lowbush blueberry fields on Prince Edward Island.

Development of bumble bee colonies can be effected by landscape type, shape, and configuration. Our study measures relationships between landscape metrics and development of bumble bee (*Bombus impatiens*) colonies placed for one month near blueberry fields within landscapes that spanned a gradient of natural land coverage. Our results suggest proportion of natural land cover does not correlate with colony development, but landscapes with a greater proportion of grasslands produce larger bumble bee colonies in terms of weight of the hive, number of workers, and brood production. Landscape configuration also had no significant impact on colony growth or reproduction.

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Impact of agricultural intensification and landscape on *Bombus impatiens* in southern Québec.

Bumble bees are efficient and essential pollinators for numerous crops. However, scientists are increasingly concerned about their status worldwide. Indeed, their global decline has been related to several hypothetical causes involving factors such as landscape homogeneity and intensive agriculture. In order to investigate the effects of agricultural intensification and landscape composition and configuration on colony development, we undertook a field experiment in spring 2016. We hypothesized that colonies bordered by low intensity crops in heterogeneous landscapes would better develop than colonies bordered by high intensity crops in homogenous landscapes. To test this hypothesis, we placed four bumble bee colonies in each of 20 sites located along a gradient of agriculture intensity in Southern Québec. Once a week, we recorded the number of bumble bee workers entering and exiting each colony as well as the weight of the quads. The availability of floral resources was assessed every two weeks. At the end of the season, we froze the quads and counted the number of queens, parasites, and predators, as well as measured the size and weight of the nest of each colony. Landscape composition was characterized within 1 km of colonies. As predicted, the size and weight of nests, as well as the weight of quads, were positively

influenced by the number of crops found within 1 km of colonies. Contrary to our expectations, the number of queens was negatively correlated with the number of crops. Worker activity (entries and exits) and the occurrence of parasites or predators were not affected by crop richness.

Sawyer Olmstead, G. Christopher Cutler

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Pollinators and pollination of haskap in Southern Nova Scotia.

Haskap is an emerging crop in N.S that relies on cross-pollination for fruit production. Due to the early blooming period, there are concerns regarding what native pollinators are available to supplement managed honey bees, and what pollinators are best-suited for haskap in N.S. In spring of 2016 and 2017, pollinator availability, effectiveness and efficiency were measured through pan trapping, transect walking, single visit pollen deposition, flower visits per minute, and other endpoints. Our results indicate honey bees can be effective pollinators of haskap, but bumblebees appear to be the most efficient pollinators.

D. Susan Willis Chan, Beatrice Chan, Nigel Raine

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Evaluation of three commonly used insecticides on health indices and pollination efficiency of the hoary squash bee, *Peponapis pruinosa*, on Table Star squash (*Cucurbita pepo*) in Ontario.

In Ontario, the most common pollinator of pumpkin/squash (*Cucurbita* spp.) crops is the hoary squash bee (*Peponapis pruinosa*). However, hoary squash bees are at particular risk from systemic insecticides commonly used in pumpkin/squash production systems to control the cucumber beetle. Here we evaluate the effect of three common systemic insecticide formulations on squash bee nest establishment, foraging behaviour, and pollination efficiency under field realistic conditions.

Asha Wijerathna¹, Héctor Cárcamo², Maya Evenden³

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Larval and adult feeding of pea leaf weevil (Coleoptera: Curculionidae) on its reproductive hosts in Alberta.

The pea leaf weevil, *Sitona lineatus* L. (Coleoptera: Curculionidae), is an invasive pest of field peas (*Pisum sativum* L.) and faba beans (*Vicia faba* L.) in Alberta and Saskatchewan. Recently the weevil expanded its range northwards to the Parkland Ecoregion of these provinces. Pea leaf weevil adults are oligophagous on legume plants (Fabales: Fabaceae) during their non-reproductive phase, but require field pea and faba bean to produce eggs and for larval development. Larvae feed on nitrogen-fixing *Rhizobium* bacteria associated with the root nodules of reproductive host plants. Adult feeding produce a characteristic notching pattern on leaves, but may not impact yield. Here, we compare the larval and adult feeding of pea leaf weevil on peas and faba bean. Host acceptance and host preference behaviours of adult pea leaf weevils to

pea and faba bean were tested with no-choice and choice tests, respectively. The impact of larval feeding on pea and faba bean nodulation was compared at two different seedling stages using several root nodule characteristics. Preliminary results indicate that adult weevils equally accept both hosts, but prefer to feed on faba bean compared to peas when given a choice. Females feed more compared to males. Experiments are ongoing in testing the larval feeding on nodulation in both hosts. The findings of this study will improve our understanding of host acceptance and preference of pea leaf weevil and the intensity of larval and adult damage on its reproductive hosts.

Diana Fernández, Sherah VanLaerhoven, Roselyne Labbè
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Oviposition preference and host suitability for the development of *Anthonomus eugenii* in southern Ontario.

The pepper weevil, *Anthonomus eugenii* Cano is a major pest of cultivated pepper plants (*Capsicum* spp.). The weevil is thought to be native of Mexico but it is present in Central America, United States, and some Caribbean Islands with recent outbreaks in Ontario, Canada. Although the weevil develops in cultivated *Capsicum* plants, prevalence in infestation varies among cultivars, and it is occasionally found in wild *Solanum* species -commonly known as nightshades- when pepper plants are not available. In Ontario, climbing nightshade (*S. dulcamara*), eastern black nightshade (*S. ptycanthum*), and hairy nightshade (*S. sarrachoides*) are commonly found in agricultural lands, and may contribute to the establishment and maintenance of *A. eugenii* in the field. We tested the preference in oviposition of pepper weevil in three pepper varieties (chili, hot cherry, and habanero) using choice experiments, and the suitability for insect development in three alternate hosts species present in southern Ontario. Our results showed that pepper weevil oviposited in all hosts tested, however, females oviposited more in chili and hot cherry varieties compared to habanero. In addition, pepper weevil females were able to oviposit and develop in all alternate hosts species tested suggesting that these species may have the potential to maintain pepper weevil populations in the field. Although additional experiments are required to test the importance of alternate hosts in the dynamics of *A. eugenii*, our findings provide information that can serve to develop a pest management program for this species.

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Effect of oviposition and herbivory by a specialist, diamondback moth on subsequent oviposition and herbivory by generalist, bertha armyworm.

Canola is a major oilseed crop grown in the Prairie Provinces of Canada.

Diamondback moth (DBM), *Plutella xylostella*, is a specialist herbivore on plants in the Brassicaceae and is considered a significant pest of canola. Bertha armyworm (BAW), *Mamestra configurata*, is a generalist herbivore that also feeds on canola plants. Plant-induced defenses to herbivory by DBM may alter the susceptibility of

canola to herbivory by BAW. In this study, we tested the effect of DBM oviposition and larval feeding on subsequent host use by BAW. We subjected DBM-infested, mechanically damaged and uninfested canola plants to subsequent BAW oviposition and herbivory. Bertha armyworm larvae were negatively influenced by DBM feeding damage whereas BAW oviposition was not affected. When exposed to canola plants with DBM eggs, however, BAW adults laid more eggs than on uninfested plants. Bertha armyworm larvae also fed more on plants with DBM eggs. We collected volatile organic compounds released from canola plants after DBM herbivory to understand the underlying mechanism driving this differential host use by BAW. The plant defensive response was also measured directly through analysis of salicylic acid (SA) and jasmonic acid (JA). Levels of SA and JA in plants with DBM eggs were lower than those in the respective uninfested samples. All together, these results suggest that DBM herbivory increased resistance to BAW herbivory whereas DBM oviposition increased susceptibility to BAW herbivory.

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Something old, something new: revisiting the diamondback moth life table on the Central Experimental Farm after 65 years.

Nearly 65 years ago, Doug Harcourt developed the first comprehensive life table of the diamondback moth (*Plutella xylostella*) on the Central Experimental Farm (CEF) in Ottawa, Ontario. To the present day this work is continually cited when authors discuss the life history of the diamondback moth and its parasitoids in Canada. Since the time of Harcourt's work, the techniques used in life tables and their analysis have changed. We also know a great deal more about the ecology and biology of the diamondback moth. Since the time of the original life table study, climate change may have altered the population dynamics of both the diamondback moth and its natural enemies. Two methods of constructing a life table were used. The first life table is influenced by the methods used in Harcourt's thesis and is an established crop based life table with destructive sampling. The second life table is a contemporary one that is cohort-exposure based using sentinel plants from the lab. A life table of the diamondback moth is indispensable in integrated pest management, since it will describe, among other factors, the composition of natural enemies attacking the diamondback moth, with emphasis on mortality caused by parasitoids.

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Performance of *Tuta absoluta* and their natural enemies on tomato resistant plants.

We evaluated in the field, the performance of the tomato leafminer (*Tuta absoluta*) and its biological control agents on four resistant genotypes: two of *Solanum lycopersicum* (BGH674 and BGH1497) and two of *S. habrochaites* (BGH6902 and PI127826). The

susceptible variety, Santa Clara, was used as a control. The plants were infested with adults and the performance of the offspring was evaluated every day until they became adults. Plant resistance against *T. absoluta* was greater in the *S. habrochaites* genotypes; biological control observed in these genotypes was lower. Therefore, the performance of tomato leafminer was similar in all tomatoes genotypes.

Rachel Rix, G. Christopher Cutler

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Does multigenerational exposure to low doses of imidacloprid precondition *Myzus persicae* to withstand insecticide stress or induce mutations in nicotinic acetylcholine receptors?

Hormetic preconditioning, whereby exposure to mild stress primes an organism to better tolerate subsequent stress, is well documented. It is unknown if exposure to hormetic concentrations of insecticide can trans-generationally prime insects to better tolerate insecticide exposure, or whether exposure to hormetic concentrations of insecticide can induce mutations in genes responsible for insecticide resistance. Using the aphid *Myzus persicae* (Sulzer) and insecticide imidacloprid as a model, we examined if exposure to mildly toxic and hormetic concentrations of imidacloprid reduced aphid susceptibility to insecticides across four generations, and whether such exposures induced mutations in the imidacloprid binding site in post-synaptic nicotinic acetylcholine receptors. Chronic, multigenerational exposure of aphids to hormetic concentrations of imidacloprid primed offspring to better survive exposure to certain concentrations of imidacloprid, but not exposure to spirotetramat, an insecticide with a different mode of action. Exposure to hormetic and mildly toxic concentrations of imidacloprid did not result in mutations in any of the examined nicotinic acetylcholine receptor subunits. Our findings demonstrate that exposure to hormetic concentrations of insecticide can prime insects to better withstand subsequent chemical stress, but this is dependent upon the insecticide exposure scenario, and may be subtle over generations.

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Effects of seed mixture sowing with transgenic *Bt* rice and its parental line on the population dynamics of target stemborers and leafrollers, and non-target planthoppers.

The widespread planting of insect-resistant crops has caused a dramatic shift in agricultural landscapes, thus raising concerns about the potential impacts on both target and non-target pests. In this study, we examined the potential effects of intra-specific seed mixture sowing with *Bt* rice (hereinafter referred to as *Bt*) and its parental line (*Nt*) [100% *Bt* rice (Bt_{100}), 5% non-transgenic+95% *Bt* ($Nt_{05}Bt_{95}$), 10% non-transgenic+90% *Bt* ($Nt_{10}Bt_{90}$), 20% non-transgenic+80% *Bt* ($Nt_{20}Bt_{80}$), 40% non-transgenic+60% *Bt* ($Nt_{40}Bt_{60}$), and 100% non-transgenic rice (Nt_{100})] on target and non-target pests in a 2-year field trial (2013 to 2014) in southern China. The

occurrence of target pests, *Sesamia inferens*, *Chilo suppressalis* and *Cnaphalocrocis medinalis*, decreased with the increased ratio of *Bt* rice, and the mixture ratios with more than 90% *Bt* rice (Bt_{100} and $Nt_{05}Bt_{95}$) significantly increased the pest suppression efficiency, with the lowest occurrences of non-target planthoppers, *Nilaparvata lugens* and *Sogatella furcifera* in Nt_{100} and $Nt_{05}Bt_{95}$. Furthermore, there were no significant differences in 1,000-grain dry weight and grain dry weight per 100 rice plants between Bt_{100} and $Nt_{05}Bt_{95}$. Seed mixture sowing of *Bt* rice with $\leq 10\%$ (especially 5%) its parent line was sufficient to overcome potential compliance issues that exist with the use of block or structured refuge to provide most effective control of both target and non-target pests without compromising the grain yield. It is also expected that the strategy of seed mixture sowing with transgenic *Bt* rice and non-transgenic parental line would provide rice yield stability while decreasing the insecticide use frequency in rice production.

8:30- 12:15 Monday

President's Prize: Student Competition Oral Presentations: Ecology

Jessica Rodgers¹, Richard Westwood¹, William Watkins²

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The effects of livestock grazing on vegetation and lepidopteran communities in imperilled alvar sites in Manitoba's interlake.

Alvars are globally rare, diverse, unique ecosystems that are listed under Manitoba's Endangered Species and Ecosystems Act as endangered. No specific alvar sites have been designated for protection in Manitoba, so economic activities, such as grazing or mining, are not regulated in these areas. Alvar soils are characteristically thin and can be damaged by livestock grazing activities, and this may affect the vegetation and pollinator communities adversely. The objective of my study is to determine if grazing negatively impacts diversity of Lepidoptera in Manitoba's alvars. I conducted surveys of physical characteristics, vegetation and Lepidoptera (moths and butterflies) in six alvar sites, three of each treatment (grazed and ungrazed) in the Interlake area of central Manitoba. Vegetation was sampled using a nested quadrat method. Moths and butterflies were sampled using different methods based on the nocturnal and diurnal tendencies of these groups of animals. I expect the soil condition will determine the plant community composition, which in turn determines the lepidopteran community. The purpose of this study is to determine the effects of grazing in alvars to assist provincial land managers in determining the best management practices for preserving pollinators as part of a long-term alvar management strategy. This study is being partially sponsored by Manitoba Department of Sustainable Development (Wildlife Branch) and the results will be presented directly to policy makers, to aid their decision making process regarding the protection and management of alvars.

Giselle Bezanson^{1,2}, Kevin Floate²

¹Department of Biology, University of Lethbridge, Lethbridge, AB; ²Lethbridge Research and Development Centre, Agriculture and Agri-Food Canada, Lethbridge, AB; giselle.bezanson@uleth.ca

Assessing the diversity of dung beetles (Coleoptera: Scarabaeidae) in pasture and forested areas in southern Alberta.

Bio-turbation activity of dung beetles facilitates nutrient cycling, while also reducing breeding sites for pest flies and parasites of livestock. Dung beetle diversity has been documented in North America, mainly on grassland pastures while very few studies have focused on forested pastures. To address this lack of knowledge, two sites in southern Alberta were chosen to assess and compare the diversity among both pasture grass lands and forested areas. Purple Springs (PS), is a low elevation (720 m) pasture with only native grass land (n=10 traps). Cypress Hills Interprovincial Park (CH), is a high elevation (1400m) pasture that has both grassland (n=10 traps) and forested areas (n=10 traps). Each trap was emptied and rebaited weekly with bovine dung between May and October. In Year 1 (2016) of this 2-year study, 23 122 dung beetles were collected: 21 308 = PS, 1 512 = CH (grassland) and 302 = CH (forest). The difference in elevation between the two sites could suggest the large difference in catches as well as the differences in dominant species, *Diapterna hamata* at CH and *Chilothorax distinctus* at PS. However, these same differences also occurred between the forested and pasture areas within CH, which documents a direct effect of tree cover. Year 2 of this study is currently underway.

Emily Hanuschuk, Melanie Dubois

Brandon Research and Development Centre, Agriculture and Agri-Food Canada, Brandon, MB; ejhanuschuk@gmail.com

Two-year native bee survey in Brandon, Manitoba.

A wild bee survey was conducted from June through August of 2016 and 2017 at the Brandon Research and Development Centre in Brandon, Manitoba. The purpose was to assess native bee biodiversity amongst cultivated land and to test for trap colour preference. Bees were sampled using nine pan traps composed of equal numbers of blue, yellow and white spray-painted 18 oz plastic cups filled half-full with soapy propylene glycol. Each trap was attached to a post approximately one half-meter above the ground and five meters apart along one transect in a repeating triplet pattern, which changed after every sampling period. After one week, the trap contents were strained and placed into plastic bags according to trap colour. Simpson's Index of Diversity (1-D) was used to assess the biodiversity of bees caught in each year, where a lower value represented less diversity. To assess trap colour preference, several unpaired T-tests were used to compare the bees caught in the three trap colours for both years. There were 651 bee specimens caught and identified overall, belonging to 10 genera and 5 families (Apidae, Andrenidae, Halictidae, Megachilidae and Melittidae), although >80% of the specimens caught in each year belonged to one family (Halictidae). Simpson's Index values were calculated to be 0.20 and 0.45 in 2016 and 2017, respectively. These values were considered to indicate low diversity, which was due to the heavy dominance of *Halictus* species in each year. It was found that blue cups were preferred significantly over yellow and white cups at a confidence interval of

90%. Family colour preference was not studied due to sample size constraints in four out of the five families.

Victoria MacPhail¹, Leif Richardson², Sheila Colla¹

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Assessing the risk of extinction of the American Bumble Bee (*Bombus pensylvanicus*) in Canada, and the role citizen scientists can play in its conservation.

Many species of bumble bee (*Bombus*) are in decline and conservation efforts must be undertaken now to lessen or reverse the trend. For effective efforts to take place, the first step must be an accurate assessment of extinction risk. Yet very few assessments have been completed in Canada: only four of over forty native *Bombus* species have been assessed by COSEWIC. Despite evidence of decline in the United States, and an overall range (North and Central America) assessment of Vulnerable by the IUCN Red List, the risk of extinction has not yet been assessed for the American Bumble Bee, *B. pensylvanicus*, in Canada. A challenge with all assessments is obtaining adequate data coverage temporally and spatially. Citizen science is a growing field that has the potential to help, as volunteers can collect data similar to that of experts (depending on skill level required and training provided), over a broader coverage than a research team could often cover alone. Launched in 2014, BumbleBeeWatch is a North American citizen science program where volunteers upload photos of *Bombus* to a website, which experts then identify. We used data from this program, a database of North American *Bombus* records representing field survey and insect collection records dating from the mid-1800s, and our own field surveys over the last decade to evaluate the status of *B. pensylvanicus* in Canada using IUCN criteria. We found that it has greatly declined, and will use our findings to help inform future conservation management of this species in Canada.

Justis Henault, Richard Westwood

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Association of the endangered Poweshiek Skipperling (*Oarisma poweshiek*) with potential larval host species in Manitoba.

The Poweshiek Skipperling (*Oarisma poweshiek*) (PS) is an endangered butterfly endemic to the tall grass prairie in North America. Historically occurring in Manitoba, Canada and in the northern mid-west states in the United States, the PS is now only found in the Tall Grass Prairie Preserve (TGPP) in Manitoba, in Wisconsin at the Puchyan Prairie and in Michigan at four small prairie fen sites. Habitat loss is the primary factor contributing to the decline of this species but biological and structural factors within PS habitat also regulate PS survival. Poweshiek Skipperling requires microhabitats with certain characteristics for adult nectar feeding, basking, reproduction, and provision of food and shelter requirements for immature stages. We assessed a component of the plant community (grass, rush, sedge) that acts as potential larval hosts in areas where the abundance of adult Poweshiek Skipperling differs between sites. The plant community was assessed along a moisture gradient where adult PS is abundant to determine if specific cool and warm season grass host plants

are linked to ideal microhabitat for immature PS development. Adult PS are more associated with drier upland patches dispersed among wetter areas. The close proximity of appropriate growing conditions of upland and wetland plant species is thought to enable larvae to access several species of host plants throughout the year. Results from this study will help direct current management activities and future research and reintroduction efforts involving the Poweshiek Skipperling in Manitoba.

Melanie Lalonde, Jeffrey Marcus

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Biogeographical analysis of morphological variation and mitochondrial haplotypes reveals cryptic species and hybrid zones in the *Junonia* butterflies of the American Southwest and Mexico.

The American Southwest and northern Mexico have a significant degree of endemic diversity, when compared to the rest of North America. The biodiversity found within this region can be attributed to the Pleistocene glaciations and the subsequent dispersal of species from glacial refuges from within this region. The New World species of the genus *Junonia* are a recently diverged group of butterflies that are thought to have sheltered in the glacial refuges of this region during periods of glacial advance. Using phenotypic and genotypic information from preserved specimens in museum collections, we reconstructed the plausible historic movements, and the contemporary geographic distributions of the five *Junonia* taxa (*J. coenia*, *J. coenia grisea*, *J. litoralis*, *J. nigrosuffusa*, and *J. zonalis*) that are currently found in the American Southwest and Northern Mexico. Utilizing both morphological characteristics and mitochondrial haplotype data, evidence of hybridization and cryptic species were found. Two morphologically similar taxa, *J. coenia coenia* and *J. coenia grisea*, were found to have differences in morphology, native larval host plants, life history traits, nuclear wingless allele frequencies, and distinct mitochondrial haplotypes suggesting that they are a cryptic species pair. Based on this evidence we suggest elevating *J. grisea* to full species status.

Antonia Musso¹, Allan Carroll², Maya Evenden¹

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Pine wars - a new host: mountain pine beetle attack dynamics in its expanded range in northern Alberta.

Climate change has facilitated forest insect range expansions into higher latitudes and elevations. Range expansions of phytophagous insects can result in contact with new hosts. The range of mountain pine beetle, *Dendroctonus ponderosae* (Coleoptera: Curculionidae), has now expanded to include northern Alberta, where attack of evolutionarily naïve lodgepole pine and jack pine hosts has occurred. Through pheromone-mediated mass attack, mountain pine beetles can overcome tree defences and kill vigorous trees. The current understanding of mountain pine beetle attack dynamics is from studies performed in their historic range, which may not be applicable to the naïve hosts in the expanded range. In the historic range, the minimum attack density required to overcome tree defences and achieve mass attack is ≈ 40

attacking beetles/m². The optimal attack density where defences are overcome and before intraspecific competition reduces brood success is ≈ 60 attacking beetles/m². Naïve lodgepole pine, jack pine, and their hybrids have a lower level of defence compared to lodgepole pines in the native range. To test whether naïve hosts in Alberta have differing attack dynamics, we are manipulating attack densities in lodgepole, jack, and lodgepole \times jack hybrid pines in various locations in northern Alberta. We are measuring how different attack densities influence beetle brood success and dispersal capacity. Since mountain pine beetle population dynamics are driven by population density changes, our understanding of attack dynamics in the expanded range will be integral to predicting beetle-caused disturbances that are currently happening and into the future.

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Where in Canada is the best place to live if you are a pigeon?

Rock pigeons (*Columba livia*) were introduced to North America in the 1600s and are now found in almost all urban centres. In addition to birds themselves being introduced, their ectosymbionts were also introduced. The ectosymbionts associated with pigeons are chewing lice (Insecta: Phthiraptera: Menoponidae and Philopterae) and feather mites (Acariformes: Astigmata: Analgoidea and Pterolichoidea), both of which are permanent ectosymbionts and therefore complete their entire life on their host. In order for an ectosymbiont to be present in a location, its host must be there, but the presence of a host does not guarantee the presence of the ectosymbiont. To investigate if the presence and intensity of ectosymbionts infesting pigeons change based on geographic location, pigeons from across Canada were collected and their ectosymbionts examined. Ectosymbiont assemblages varied greatly in both species present and intensity of individuals based on location, with locations on the east and west coasts having a species of feather mite (*Pterophagus* sp.: Falcuiferidae) that did not occur elsewhere and had higher intensities of ectosymbionts. Warmer and more humid coastal climates may have allowed persistence of this species, or its presence may be from independent introductions of pigeons and their ectosymbionts in these areas. Molecular analyses are in progress to assess connectivity between host and louse population structure.

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Advanced castes at the outset of eusociality in wasps (Vespidae).

A widespread view is that evolutionary change waits upon mutation, and thus is gradual and stepwise. Likewise, it is thought that the origin of eusociality in wasps was preceded by casteless nest-sharing, and that workers and queens diverged gradually. This paradigm hinges on eusociality having evolved once in Vespidae, and the earliest eusocial ancestors having rudimentary castes that lacked any morphophysiological differentiation prior to adulthood. Here we show that eusociality originated twice in vespid wasps, wherein one origin is inferred to have had advanced castes at the outset.

Thus, the paradigm of stepwise social evolution is rejected. The phylogeny of vespids supports a subsocial route to eusociality, emphasizing interactions between mothers and daughters and the cost component of kin selection in explaining the origins of eusociality. We hypothesize that phenotypic plasticity and standing genetic variation explain how solitary (not nest-sharing) vespids transitioned into eusociality, and advanced castes abruptly emerged.

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Revision of the South American Thaumaleidae (Diptera).

Thaumaleidae, commonly referred to as madicolous midges, are a small family of aquatic Diptera. The common name refers to the larval habitat, which is always a thin film of flowing water (*i.e.*, madicolous). These habitats include waterfalls, vertical rock-face seepages, splash zones around waterfalls and along cascading mountain streams. Due to this habitat specificity, thaumaleids are poorly known and rarely collected. The Neotropical fauna has not been studied in detail since 1930 and is comprised of six species within three genera; all known from Chile and Argentina. The main objectives of this research were to: (1) more accurately assess the diversity of the Chilean Thaumaleidae (redescribe known species and describe new ones); (2) provide DNA fingerprints that will allow current and subsequent researchers to readily identify species in all life stages; (3) construct keys to aid in species identification; (4) construct the first phylogenetic tree to investigate relationships among Neotropical species and between them and their nearest relatives. In addition to the Chilean revision, newly acquired material from Brazil was examined morphologically and molecularly. Nucleotide sequences from the nuclear genes Big Zinc Finger and Molybdenum Cofactor Sulfurase were acquired from all available species and several outgroup taxa, and then analyzed phylogenetically using modern likelihood-based methods. The Chilean species are revised to include 10 species: three spp. of *Austrothaumalea*, six spp. of *Niphta* (four newly discovered) and one sp. of *Oterere* (not collected). The material from Brazil is identified as a new genus of Thaumaleidae.

Ryan Oram¹, Cory Sheffield², John Stavrindes¹

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Out of the woods: revising *Hylaeus* taxonomy.

Masked bees within the genus *Hylaeus* Fabricius can be commonly found across Canada, but due to their small size (4-9 mm) and wasp-like appearance, are often overlooked in the field. Morphological variation makes identification of these bees very difficult and tedious, and has resulting in many synonymies. Out of the 167 proposed names only 51 are recognized in North America, north of Mexico. However, the synonymies were made using only the presence or absence of maculations and there is the possibility that these were ill grouped. Because of this the number of recognized species is possibly underestimated. Using a combination of morphology and DNA sequencing the goal of my project is to create a complete taxonomic key for the Canadian members of this genus. Species groups are created by using percent

divergence of DNA sequences from the barcode region (658bp sequence from the CO1 gene). Once species groups are determined morphologic comparisons are conducted to determine how to differentiate the species from one another. Comparisons to type specimens allow for assigning names to each species group. Using barcoding allows for the association of species who are morphologically variable across the country, and for associating males and females of species where only one sex is described, both instances occurring in *H. gaigei* Cockerell. Resolving synonymies also occurs when barcoding is applied to *Hylaeus. H. modestus* Say and *H. mesillae* Cockerell are two species that currently have many synonymies, that when barcoded separate into multiple possible species.

Sarah Dolson, Elyssa Loewen, D. H. Janzen, W. Hallwachs, M. Alex Smith
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Diversity and community structure of Staphylinidae across a neotropical elevation gradient.

As elevation increases, environmental conditions can become physically stressful for the resident invertebrate communities. Stressful conditions such as these can act as an environmental filter on the taxa able to survive here and in doing so can change a community's composition and structure. This filtering hypothesis predicts that species present will be less diverse, more specialised and (if phylogeny and function are coupled) more closely related. We test for such trends amongst one of the most abundant leaf litter fauna, the rove beetles (Coleoptera: Staphylinidae). Staphylinids have been collected across a 1500 m elevation gradient in Area de Conservación Guanacaste in Costa Rica for nearly a decade. This montane slope contains a gradient of environmental stress as habitats here range from hot and dry forests to cold and wet montane cloud forests. To measure changes in the community structure of staphylinids across this gradient we use DNA barcodes, functional morphometrics, and phylogenetic estimates of community structure. Preliminary results suggest that diversity does not increase across elevation, and that low elevation communities are phylogenetically clustered high elevation communities are phylogenetically clustered in the high elevation montane cloud forest. Ongoing research is investigating functional responses occurring at these clustered sites. Neotropical staphylinids are a largely understudied taxon and using barcodes and standardised functional measures to characterise biogeographical patterns (such as elevation) will help to predict and understand how these communities react to global climate change.

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Molecular characterization of *Chilo partellus* using Mtco1 gene as marker from Pakistan.

PCR amplification and DNA sequencing of mtco1 region is more informative and explanatory approach in molecular characterization. Lab work was performed for the characterization of *Chilo partellus* using Mtco1 gene as marker. This present study is the first report for the genetically identification and characterization of any lepidopteran in Pakistan. Mitochondrial genomes were very helpful in understanding

and reconstructing the phylogenetic relationships within lepidopteran species. Present study with the application of DNA sequencing helped in revival of taxonomic study of *C. partelus*. Data obtained after the complete sequence of CO1 gave the exact identification of this insect representing the whole order. Results obtained were similar to the results of *C. partelus* identified in Kolhapur India. It will help in understanding the geographic distribution of this pest for a specific area and also for over the globe and also in studying the evolution of new specie/strain.

8:30- 12:00 Monday

President's Prize: Student Competition Oral Presentations: Biocontrol

Caitlin Mader¹, Nadir Erbilgin¹, Jim Watts²

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Field studies of fecundity effects of *Coccophagus gossypariae* (Hymenoptera: Aphelinidae) and its host, *Gossyparia spuria* (Hemiptera: Eriococcidae).

European elm scale (*Eriococcus spurius*) is a pest of urban elm trees in western North America, but no effective biocontrol agent has been found to manage it. A barrier to the study of biocontrol agents specific to tree pests is the difficulty of imitating mature tree centred systems in a greenhouse, where insect population and life history studies can be more easily controlled. We present a method designed to address some of the challenges of moving life history studies from the greenhouse to the field, where a more complete story can be told. We documented the life history of *Coccophagus gossypariae*, a little studied aphelinid parasitoid of European elm scale. This wasp is native to Europe, but is established on European elm scale in Calgary, Alberta. In this system, the relative timing of parasitoid and host life cycles is especially important to the impacts of the parasitoid on its host's populations, as the parasitoid's effects on host fecundity are more important than its effects on host mortality. We also examined other environmental conditions required to maintain European elm scale populations at levels meeting management objectives, as this system requires a suite of approaches available to urban foresters to effectively manage European elm scale.

Charles-Etienne Ferland, Rebecca Hallett

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Distribution, abundance and biological control potential of the swede midge parasitoid, *Synopeas myles*.

The swede midge, *Contarinia nasturtii* (Diptera: Cecidomyiidae), is a pest of *Brassica*. Distribution and abundance of its parasitoid, *Synopeas myles* (Hymenoptera: Platygasteridae), are being determined in Ontario canola agroecosystems. Infested canola plants are collected from the field throughout the season and placed within emergence containers. Samples are monitored for parasitoid and swede midge presence. Prevalence of parasitism is being determined for each site.

Arash Kheirodin¹, Alejandro Costamagna¹, Héctor Cárcamo²

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Landscape structure effects on the abundance of the cereal leaf beetle, *Oulema melanopus* (Linnaeus) (Coleoptera: Chrysomelidae), and its parasitoid, *Tetrastichus julis* (Walker) (Hymenoptera: Eulophidae).

The cereal leaf beetle is an invasive pest of cereal crops expanding its range in the Canadian Prairies. This study was conducted in southern Alberta to determine effects of landscape structure on the abundance of CLB, and parasitism by *Tetrastichus julis*. The abundance and percentage parasitism of cereal leaf beetle were assessed in 30 wheat fields in 2014 (13 spring wheat and 17 winter wheat fields), and in 43 wheat fields in 2015 (17 spring wheat and 26 winter wheat), from 10 May to 30 July. The average percentage parasitism was 55% and 34.59 % in 2014 and 2015, respectively. The average cereal leaf beetle abundance was 25.12 and 6.14 larvae per 50 sweeps in 2014 and 2015, respectively. The main land cover types found in the landscapes sampled were cereals, canola, semi-natural habitats (grass, fallow, trees, ditch, riparian, and barnyard) and other crops (rye, beans, beets, hay, corn, alfalfa, oats, peas, and sunflower). Multiple regression models for 2014 suggest that cereal leaf beetle abundance and percentage parasitism respond positively to increased semi-natural habitats, canola and other crops in the landscape. By contrast, a higher proportion of barley in the landscape decreased parasitism in focal wheat fields at the 1000 m scale. Contrary to our expectations, cereal leaf beetle abundance was not correlated with the percentage of wheat in the landscape. This information can be used to select sites to release *T. julis* that maximize its establishment and the control of cereal leaf beetle.

Zach Balzer, Arthur Davis

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Prevalence and anatomical investigation of a *Stylops* sp. (Strepsiptera) attacking *Andrena milwaukeensis* in Saskatoon, Saskatchewan.

The Strepsiptera is a unique order of obligate parasitoid insects comprising around 600 described species that spend the majority of their life cycle inside one host. Thus, in most species, only the first instar (triungulin) larvae and the adult males are free-living. Presence of this parasitoid can negatively affect fitness of the female host by damaging its reproductive organs, which is problematic when the host is beneficial. An important solitary bee pollinator in Saskatoon, *Andrena milwaukeensis*, was collected by sweep netting in spring-early summer of 2016 and 2017 and these adult female bees were examined microscopically for Strepsiptera. Each year, 20-25% of foraging bees of this *A. milwaukeensis* population were styloped by at least one adult female strepsipteran (*Stylops* sp.). Collection of adult males of this *Stylops* sp. in spring remains elusive, evidently because of their activity in early spring plus their short life spans. Parasitized and non-parasitized bees are being sectioned for anatomical comparison to understand the orientation and details of the occupancy of the adult female parasitoid protruding from the abdomen of its host bee, plus information about the triungulin larvae contained within the adult parasitoid. Results to date suggest that

the adult female *Stylops* occupies about half of the bee abdomen longitudinally, squeezing the hosts organs to either side of it.

Joanna Konopka¹, Tim Haye², Tara Garipey³, Jeremy McNeil¹

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Possible coexistence of native and exotic parasitoids and their impact on control of *Halyomorpha halys*.

Introduction of exotic natural enemies for biological control of invasive pests may disrupt existing ecological interactions, which may influence the outcome of biological control introductions. The interactions between Asian egg parasitoids, proposed as classical biological control agents of the highly polyphagous invasive pest *Halyomorpha halys* (Stål), and parasitoids native to the introduced area are largely unknown. Therefore, adult and larval interspecific competition between the exotic *Trissolcus japonicus* (Ashmead) and the European *Anastatus bifasciatus* (Geoffroy) was assessed (1) by observing aggressive interactions between adults of the two species following parasitism and (2) by providing each parasitoid species with previously parasitized *H. halys* egg masses at various time intervals. The results suggest that *T. japonicus* and *A. bifasciatus* engage in counterbalance competition, with the former being a superior extrinsic competitor (egg guarding and aggressiveness) and the latter being a superior intrinsic competitor (successful development from multiparasitized eggs of all ages). We suggest that the presence of *T. japonicus* is unlikely to have a negative impact on *A. bifasciatus*, and that those two species can coexist and potentially act synergistically in the biological control of *H. halys*.

Kari Zurowski¹, Jenny Cory¹, Jessi Ly¹, Danielle White², Todd Kabaluk³, Alida Janmaat²

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Trade-offs between reproduction and disease resistance in the click beetle, *Agriotes obscurus*.

Reproduction and defense against infection are both costly processes, so trade-offs between them are likely to occur, particularly if resources are limiting. We investigated possible trade-offs in the click beetle *Agriotes obscurus* after challenge with the entomopathogenic fungus, *Metarhizium brunneum*. Adult *A. obscurus* were challenged with 10^4 spores per millilitre, 10^8 spores per millilitre or a clean control of *M. brunneum* and their reproduction was monitored. Individuals varied in nutrition status in order to determine the impact of starvation. The timing and length of the oviposition period, as well as egg sizes were recorded. As expected, females that were challenged with the pathogen died earlier than unchallenged insects, which led to a reduction in the number of eggs laid, but not to a reduction in average egg sizes. Differences appear to be related to when the insects finished laying eggs, with challenged insects completing oviposition earlier. The observed differences suggest that lifespan restricted fecundity, but that this may be associated with a trade-off

favouring reproduction over disease resistance. The possible impact of nutrition on this trade-off will be discussed.

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Mixed pathogen interactions: how does host nutrition modulate disease?

Individual hosts are commonly challenged by multiple pathogen species. Yet, studies on insect-pathogen interactions mainly focus on interactions between a single host and a single pathogen. Two (or more) pathogens co-infecting a host may compete directly (interference) or indirectly, for resources or via the host immune system. These competitive interactions could increase or decrease host mortality, or result in no change, as well as alter the transmission of disease within the population. In insects, increased dietary protein can increase survival, to pathogens such as baculoviruses and bacteria, even when nutrition is altered post-infection. However, the role of nutrition in mixed pathogen infections is not known, but is likely to relate to the relative cost of resistance to different pathogen groups. Using the cabbage looper, *Trichoplusia ni*, its nucleopolyhedrovirus (TnSNPV) and the entomopathogenic fungus, *Beauveria bassiana*, we asked whether host nutrition could alter the outcome of a mixed infection. We challenged *T.ni* larvae with either a single pathogen species or two simultaneously; then reared the larvae on an artificial diet differing in levels of two major macronutrients, protein and digestible carbohydrate (quality) or the total amount of these two macronutrients (quantity). The virus and fungus may respond differently to host nutritional intake, especially on different ratios of protein and carbohydrate. As expected, poor quantity diet exacerbates the negative effect of pathogen on host survival. Moreover, in co-infection, the effect of diet composition on host mortality is greater at lower pathogen doses. Diet could be an important modulator of mixed infections.

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New insights into host specificity for classical biological control: what fundamental and ecological range tests between *Chrysochus* beetles and their novel host plants can tell us.

In weed biological control, it can be difficult to know for certain whether the host range of a biological control candidate being screened reflects its true impact under natural conditions. In particular, it is unclear whether the host range of insects tested in controlled lab or greenhouse conditions (*i.e.*, fundamental host range) will be the same as those observed in the field (*i.e.*, ecological host range), yet this is currently one of the criteria used to select potential agents for release. Here we draw conclusions about the predictive ability of the fundamental host range of *Chrysochus asclepiadeus*, a classical biological control candidate for the invasive vine *Vincetoxicum rossicum*, by studying how the North American *Chrysochus congeners* fundamental host ranges translate into their confirmed ecological host ranges. Predicted fundamental host ranges were derived for each species/hybrid in a series of standardized laboratory tests and compared to their respective ecological host ranges recorded from field surveys

across North America. In both Europe and North America, the ecological host range of *Chrysochus* beetles was found to be more limited than their fundamental host range suggesting a relatively high probability of false-positives in standardized host specificity testing. Given that traditional screening for classical biological control agents in this genus tends to overestimate the range of plant species attacked compared to the field supports the need for further investigation between fundamental and ecological host range in such novel insect-plant systems.

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Can landscape structure affect flea beetle populations in canola fields?

Flea beetles are an important pest of canola in North America. To control this pest, producers rely mostly on general insecticide seed treatments and foliar sprays. No studies have been done to explore how landscape structure mediates the interactions among canola and flea beetles. The objective of our study is to determine if landscape structure affects flea beetle populations in canola fields in the Prairies. In 2015 and 2016, we sampled 54 commercial canola fields in three Prairie Provinces of Canada (Manitoba, Alberta, and Saskatchewan). Sampling occurred on a weekly basis from late May to August, with five sticky traps (ST), totaling 145 ST and 125 ST each week, in 2015 and 2016, respectively. In each field, we also assessed levels of flea beetle defoliation in 10% intervals, ranging from 0 to 100% damage. Landscape structure surrounding the canola fields up to 2 km radius of the focal area was assessed constructing digital maps using ArcGIS. We used multiple regression models to identify landscape variables that best predict flea beetle abundance and damage in canola fields.

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The use of fitness bioassays to improve population establishment of a classical biological control agent (the psyllid, *Aphalara itadori*) for knotweeds.

Among the most aggressive and potentially damaging non-native plants in North America are the invasive knotweeds (*Fallopia* sp.). These plants are common riparian invaders where they grow in tall dense stands and have a large regenerative capacity making conventional mechanical or chemical control difficult. As an additional control method, the psyllid, *Aphalara itadori*, was recently approved for release as a biological control agent for invasive knotweeds in Canada. Early stage biocontrol release programs are often plagued with uncertainty as population establishment rates are variable and little is known as to how agents will behave in the field. To help inform how field releases of *A. itadori* will perform, we developed a series of laboratory bioassays to assess the psyllids fecundity and offspring fitness in response to knotweed host plants of varying quality. Initial results suggest an adaptive response by the offspring as they are shown to preferentially oviposit on host plants similar to

natal hosts. These data may imply *A. itadori* population establishment rates could be improved by first rearing an in-lab generation of the insects on plants of similar quality to those found in field release sites prior to release.

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Biocontrol of varroasis in honey bees: assessment of *Stratiolaelaps scimitus* predation on phoretic varroa mites.

The ectoparasitic mite, *Varroa destructor* (Acari: Varroidae), is considered the most important pest of honey bees worldwide and plays an important role in colony losses. Repeated use of chemicals has led to mite resistance. Thus, the development of new methods of control has become a research priority in the beekeeping industry. The predatory mite, *Stratiolaelaps scimitus* (Acari: Laelapidae), appears to be particularly promising as a biocontrol agent against varroa and preliminary tests have confirmed its potential to attack and feed upon *V. destructor*. The aim of the study was to evaluate the predation potential of *S. scimitus* on phoretic varroa mites. Modified plastic pill bottles filled with 1 cm of moistened vermiculite served as experimental arenas. Twenty starved adult female predators were transferred to each treated arenas (n=40) whereas control arenas (n=40) received no predators. Then, an adult bee parasitized with one female varroa mite was inserted in each arena and fed daily with sucrose solution. Arenas were held in a growth chamber (30C, 75% RH, darkness) throughout the duration of the test (1 to 11 days). Once a day, bees and parasites were observed and recorded as dead or alive. When a varroa mite was found dead, it was carefully checked under the stereomicroscope for evidence of predation. *Stratiolaelaps scimitus* did not attack varroa mites when attached to the body of bees. However, all varroa mites that had fallen into vermiculite were predated by *S. scimitus*, and died in less than 24 h.

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Stand factors affecting the abundance and impact of North American parasitoids attacking the emerald ash borer across southern Ontario.

Stand-level characteristics, including tree species composition, stand density, and canopy closure, have been shown to differentially impact parasitoid species in the field and may help explain the natural variation in parasitism observed on the recently introduced emerald ash borer, *Agilus planipennis* Fairmaire (Coleoptera: Buprestidae) (EAB). We investigated the influence of stand variables on the abundance of native North American parasitoids attacking EAB and other *Agilus* species and their role in EAB mortality to better understand mechanisms driving the distribution of parasitism across sites. We selected 30 stands across a range of ash density (*i.e.*, % biomass) throughout southern Ontario, and in each, set up a circular plot (400 m²) in which sticky band traps were installed on five *Fraxinus* L. (Lamiales: Oleaceae) (ash) trees (or the most dominant broadleaf tree(s) if the plot contained less than five ash trees). Traps were sampled every two weeks from May to September in

2016 and again in 2017. Each plot was characterized using the Vegetation Sampling Protocol (VSP) to measure the amount of ash, tree species diversity, density of trees, tree health and condition, floral resource availability, and canopy closure. Results of this study will provide insight into the optimal strategy for augmenting parasitoid populations in a potential biological control program against EAB. Preliminary results show that the number of native EAB parasitoids is affected by select stand-level characteristics, including a decline in ash tree condition in the stand, suggesting that parasitoid populations should be augmented as early as possible into EAB-infested sites.

8:30- 11:30 Monday

President's Prize: Student Competition Oral Presentations: Physiology

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Influence of host and non-host volatile organic compounds on mountain pine beetle (*Dendroctonus ponderosae*) flight propensity and capacity.

The mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae: Scolytinae), is North America's most destructive forest pest. In the most recent outbreak, MPB has killed over 18 million hectares of mostly lodgepole pine (*Pinus contorta*) in British Columbia. Range expansion of MPB east of the Rocky Mountains into North-Central Alberta on the edge of the boreal forest has resulted in colonization of a novel host, jack pine (*Pinus banksiana*). Although the ecology of MPB is well studied, much remains to be learned about its dispersal capacity. Both host and non-host volatile emissions are important in the host colonization behaviour of MPB, but it is unknown whether host and non-host volatile organic compounds influence the flight propensity and capacity of MPB distinct from an oriented flight response. Computer-linked flight mills were used to measure MPB flight propensity and capacity when in the presence of volatiles from the phloem of a traditional host-lodgepole pine, a novel host- jack pine, and a non-host- trembling aspen (*Populus tremulodes*), as compared to a clean air control. Flight propensity, flight distance, speed, and duration over the 22-hour flight assay were recorded for each individual beetle flown. These data, and other research currently ongoing at the University of Alberta, will aid in understanding the potential future range expansion of MPB.

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Genetic and morphological basis of dispersal capability in mountain pine beetle (*Dendroctonus ponderosae*).

In recent years, mountain pine beetles (MPB), *Dendroctonus ponderosae*, have become major forest pests in Western Canada, causing immense economic losses in forestry. Dispersal by MPB is poorly understood and more thorough knowledge of its dispersal capabilities would improve predictive modelling, allowing more efficient allocation of management resources. Flight morphology and propensity are two elements that often

have an effect on flight performance; this study aims to identify morphological characters and genes associated with dispersal capability in MPB. Beetles were flown on flight mills to collect flight data, and measurements were made on the body and wings before RNA was extracted for RNA-seq and differential gene analysis. Dimensions of the wings, body and flight muscles were compared to flight performance. Multiple regression showed that some of the variation in flight performance could be explained with wing and body morphology based models; previous studies have demonstrated that body size often has relationship with dispersal capability, but this study shows that the inclusion of wing morphology can drastically improve the predictive power of this relationship. Regardless, only approximately 20% of the dispersal capability is explained by the morphology of the beetle. Quantile regression shows that morphology has a greater influence on strong dispersers while it seems to have little or no effect on weak dispersers. This suggests that behavioural traits - in particular flight propensity - are also likely to be important factors affecting dispersal capability. RNA-seq data has been collected and is being analyzed for differential gene expression associated with flight propensity.

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Synthetic aphid honeydew volatiles attract mosquitoes (Diptera: Culicidae).

Male and female mosquitoes exploit a variety of sugar sources including floral and extra-floral nectar, rotting or damaged fruit, aphid honeydew, and ant regurgitate. Plant-derived semiochemicals are thought to guide mosquitoes to inflorescences and fruit, but the cues that attract mosquitoes to other sources of plant sugar such as aphid honeydew remain largely speculative. Drawing on literature reports of aphid honeydew volatiles, we prepared synthetic honeydew volatile blends and tested their attractiveness to female *Aedes aegypti*. Here we report our findings and discuss their significance.

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Engineering a mosquito gut bacterium, *Asaia* sp., for use in symbiont-mediated NAI aimed at mosquito vector control.

Mosquitoes infect millions of people each year with life-threatening diseases such as malaria, yellow fever, and dengue fever. The Sterile Insect Technique (SIT) is an insect control method that involves the production and release of sterile males to reduce pest populations. While SIT avoids harsh chemical insecticides, it has its drawbacks, including inefficient sex-sorting and reduced mating competitiveness of the radiation-sterilized males. A potential method to produce vigorous sterile males is to treat mosquitoes with double stranded RNA (dsRNA) to induce RNA interference (RNAi) mediated knock down of male fertility and female development gene expression. However, large-scale dsRNA synthesis and delivery is costly and laborious, and thus necessitates the development of alternative dsRNA production methods. Symbiont-mediated RNAi shows considerable potential as an alternative

means of dsRNA production and delivery. A promising candidate for this technology is *Asaia* bacteria. Members of this genus densely colonize the gut and reproductive tissues of major vector mosquitoes like *Aedes aegypti*. Here, a strain of *Asaia* was isolated from *A. aegypti* mosquitoes with the intent to engineer it to produce and deliver dsRNA to host mosquito larvae. Lambda-red-mediated homologous recombination was first used to prepare an RNaseIII-deficient strain of *Asaia*. Then, a genetic construct capable of expressing dsRNA was designed, synthesized, and ligated into a broad host range plasmid. This dsRNA expression vector was then introduced into the RNaseIII-deficient *Asaia* for in vivo expression of mosquito-specific dsRNA. This *Asaia* strain, with its dsRNA expression plasmid, is a promising tool for mosquito control.

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Overcoming dsRNA degradation for successful RNAi in aedine mosquitoes.

The sterile insect technique (SIT) is a biological control method that could be used to suppress disease vector mosquitoes. Effective SIT requires both a sex-sorting capacity and an ability to sterilize males without adversely affecting their mating competitiveness. To date, sex sorting of mosquitoes relies upon mechanical methods to size-sort the insects, which can be unreliable. Male sterilization requires either infection with the endosymbiont *Wolbachia* or irradiation. Neither sterilization method has been deployed on a large scale in a developing country, due to financial and regulatory constraints. Genetic modification (GM) and gene-drive technologies provide additional options for mosquito control, but negative public opinion of GM methods has hampered their deployment. As an alternative, we are developing RNA interference (RNAi) technology for SIT against *Aedes aegypti* and *Aedes albopictus*. Feeding mosquito larvae dsRNAs that inhibit female and testis-specific genes could potentially be used to produce sterile males, but the larval gut contains nucleases that can rapidly degrade dsRNA, thereby reducing RNAi efficacy. Here, we discuss our efforts to reduce degradation of dsRNA within the insects gut by: improving the stability of dsRNA; expression of dsRNA in chloroplasts of microalgae; and inhibition of exonucleases. Our efforts to enhance RNAi efficiency to knock down expression of male fertility and female development gene expression will be discussed. Preventing RNA degradation may be the determining factor for efficient RNAi in dsRNA-fed mosquitoes. Overcoming this challenge has the potential to enable cost-effective, non-GM SIT against mosquito pests.

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Floral ultraviolet cues affect foraging behaviour of *Culex* mosquitoes.

Like other nectar feeders, mosquitoes have photoreceptors sensitive to ultraviolet (UV) light. We hypothesized that mosquitoes locate floral nectar in part by responding to UV light-reflecting nectar guides offered by many inflorescences. Previously, nectar-foraging mosquitoes were thought to respond solely to floral semiochemicals. To test

our hypothesis, we selected the northern house mosquito, *Culex pipiens*, and the common hawkweed, *Hieracium lachenalii*, as model species. Through electroretinograms (ERGs), we determined that the compound eyes of 3- to 4-day-old female *Cx. pipiens* have maximal spectral sensitivity at 340 nm (UV range) and 525 nm (green range). Spectral analysis of *H. lachenalii* inflorescences revealed that the distal portion of the ray florets reflects UV light maximally at about 360 nm, and that the proximal portion of the florets absorbs UV light. In laboratory bioassays with UV light bulbs as illumination devices, paired traps were baited with inflorescences of *H. lachenalii* that were either occluded with cheesecloth or presented on top of cheesecloth. In this two-choice experiment, significantly more 1- to 3-day-old virgin female *Cx. pipiens* were captured in traps baited with un-occluded inflorescences. When we presented the same two test stimuli but filtered out the UV wavelengths from the illumination devices, similar numbers of female *Cx. pipiens* were captured in each of the two traps. Our data provide emerging evidence that nectar-foraging *Cx. pipiens* respond to UV light-reflecting nectar guides in *H. lachenalii* inflorescences.

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Dispersal behaviour of adult nuisance mosquitoes (Diptera: Culicidae) in Winnipeg, Manitoba.

Geographic Information Systems (GIS) models are being increasingly used as tools in managing nuisance and disease-vectoring mosquito populations. To predict the distribution of mosquitoes across a landscape, these models often use trap surveillance, host distribution and climatic data in addition to hydrologic and floristic habitat features. However, mosquito dispersal patterns are poorly understood and have been neglected in these models. To determine the extent of mosquito dispersal capabilities and their relationship to climatic and habitat variables, we carried out mark-release-recapture experiments on adult mosquitoes in peri-urban Winnipeg, Manitoba. Multiple cohorts of field-reared adults were marked using fluorescent dusts and recaptured in light traps placed within 30 km of the release site. The implications of our preliminary findings will be discussed in the context of mosquito dispersal behaviour.

Future analysis of proximity relationships between adult mosquito populations and features of their environment will be integrated with these findings in new GIS models for predicting long-term mosquito distribution. These models may positively impact the management and efficiency of mosquito control measures both locally and globally.

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Heightened sensitivity in honey bees (*Apis mellifera*) and mechanisms of grooming behaviour.

The invasive ectoparasitic mite, *Varroa destructor*, is a major contributor to the deaths of honey bee colonies around the world every year. Chemical miticides are the most common controls; however, these methods are imperfect as they can lead to acaricide-resistant mites and chemical residues in wax and honey. Therefore, capitalizing on natural social-immunity behaviours, such as grooming behaviour, to breed bees resistant to varroa mites may be a good alternative method of control. Grooming behaviour has previously been studied quite thoroughly; however, one unanswered question is whether bees exhibiting higher levels of grooming behaviour are more sensitive to stimuli than low grooming bees. To test this hypothesis, bees from high and low grooming colonies were observed in a laboratory setting during the summer of 2017. Individual bees from these colonies were randomly assigned to one of three stimulus groups: one varroa mite, a standard stimulus, or a control group which was not exposed to any stimulus. Bees were observed for three minutes after exposure to each stimulus or no stimulus. We hypothesize that bees from the high grooming colonies will show increased grooming responses to both stimuli relative to low grooming colonies, indicating they have heightened sensitivity to external stimuli regardless of the source. This research has the potential to influence the pace at which varroa-resistant bees can be bred, if quicker screening techniques can be developed for these behaviours.

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Life in the fast lane phenomenal flight ability and other life history traits of *Xenos peckii* (Strepsiptera: Xenidae).

The peculiar biology of Strepsiptera has intrigued entomologists ever since Rev. William Kirby in 1811 proposed ordinal status, based on two specimens. These seldom-seen insects are notable for their extreme sexual dimorphism, whereby the neotenic females remain grub-like and host-bound throughout adulthood, whereas males pupate into a winged, albeit brief (ca. 2 hrs), adult life stage. Little is known about their sexual communication and even less about the flight ability of adult males that are deemed feeble flyers. Our study here focuses on *Xenos peckii* (Xenidae) which parasitizes North American paper wasps. We show life history traits of *X. peckii*, including (i) adult males eclosing from puparia that extrude from the abdomen of host wasps, (ii) neotenic, host-bound females engaging in sex pheromone emission, (iii) the molecular structure and attractiveness of the female sex pheromone, and (vi) males alighting on host wasps and mating with the endoparasitic female. Through 3-dimensional, high-speed, macro-videography, we characterize the astounding speed and agility of male *X. peckii* flight, and highlight unique, previously unknown aspects of Strepsiptera flight biomechanics. The footage will demonstrate that *X. peckii* males

are not feeble but most agile flyers that rival or surpass the manoeuvrability of the most advanced flying insects.

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Communication between yellow jacket wasps and their yeast symbionts.

Yellowjacket wasps in the genus *Vespula* are pests of significant medical, environmental, and economic importance. Several attract-and-kill technologies have been developed to control yellowjacket populations, but these technologies do not effectively control certain species such as the invasive German yellowjacket. Recent studies show that yellowjackets share a symbiotic relationship with certain species of fermentative yeast, and that this symbiosis may be beneficial to both the host wasp and its yeast symbionts. However, little is known about how the host and its symbionts find each other. We tested the hypothesis that yeast symbionts from the digestive tract of yellowjackets emit semiochemicals (message-bearing chemicals) that attract yellowjackets. We field-tested cultures of two yeast species growing on fruit juice-infused agar for yellowjacket attraction, analyzed their semiochemicals, and produced a synthetic semiochemical lure of these volatiles. Our data indicate that symbiotic yeasts are attractive to three species of yellowjackets, including the German yellowjacket. A synthetic semiochemical lure also elicited an attractive response from yellowjackets. Although relatively few yellowjackets were attracted to the lure, some of its semiochemical constituents could be added to current commercial lures to enhance their efficacy and target-species range, thus allowing pestiferous yellowjacket populations to be more efficiently controlled.

8:30- 11:45 Monday

President's Prize: Student Competition Oral Presentations: Pheromones

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The scent of home false black widow spiders recognize their own webs based on specific semiochemical cues.

Web-building spiders use their webs as territories and sites for hunting, mating, and nesting. If spiders are displaced from their webs by a disturbance, they are able to relocate them. Working with the web-building false black widow spider, *Steatoda grossa*, as a model species, we tested the hypothesis that web-searching spiders discriminate between their own and other spiders' webs, thereby avoiding potential conflict. In a binary choice bioassay, we offered a *S. grossa* female a choice between (a) her own web and that of a conspecific. With evidence that *S. grossa* females recognize their own webs, we further tested whether web recognition is based on specific semiochemical cues or physical characteristics associated with webs. To this end, we tested the responses of *S. grossa* females to methanol extracts of webs tested

in a) and to webs that were, or were not, solvent (methanol, hexane) extracted. Our data indicate that *S. grossa* females relocate their own webs based on specific semiochemical cues associated with webs.

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Identification and testing of the trail pheromone of the carpenter ant *Camponotus modoc*.

The carpenter ant, (CA) *Camponotus modoc*, infests man-made wooden structures and merchantable timber, weakening their structural integrity. Infestations cause economic damage because ant nests must be eradicated and structurally compromised wood replaced. Poison food baits (PFB) have great prospects for CA control as ants share food items and thereby distribute lethal poisons. Ant trail pheromones have been demonstrated to enhance the attractiveness of PFBs. Some CAs reportedly deposit trail pheromone through hindgut secretions. The trail pheromone of *C. modoc* is not known. We tested the hypothesis that *C. modoc* workers follow hindgut extracts and that these extracts contain trail pheromone. To assess trail-following behaviour with laboratory colonies of *C. modoc*, we (i) presented two diverging strips of filter paper, treating one with hindgut extract and the other with a solvent control, and (ii) applied hindgut extract, or a solvent control, around the edge of a filter paper disc and recorded the number of 1-cm circular increments that worker ants followed. As ants exhibited significant trail following in both types of bioassays, we analyzed the hindgut extract by gas chromatographic-electroantennographic detection (GC-EAD) and GC-mass spectrometry. We identified five candidate pheromone components that elicited responses from ant antennae, initiated compound syntheses, and plan to test a synthetic trail pheromone lure for its ability to induce trail following behaviour by *C. modoc*. Our data provide new information on the chemical communication system of an economically important ant species.

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Synthetic trail pheromone increases foraging on food baits by the European fire ant, *Myrmica rubra*.

The European fire ant, *Myrmica rubra*, is an invasive pest in many parts of Canada. Its presence significantly alters both invertebrate and vertebrate communities. Ants sting aggressively, rendering lawns, gardens, and parks useless for recreation. Current control methods for *M. rubra* are ineffective. Our overall research goal is to develop a highly attractive bait station for this ant, comprising food sources, the trail pheromone, and a carefully selected insecticide. When ants return from a food source to the nest, they reportedly deposit a trail pheromone (3-ethyl-2,5-dimethylpyrazine) that recruits nest mates. Here we tested the hypothesis that synthetic 3-ethyl-2,5-dimethylpyrazine increases ant foraging on food baits. We tested the responses of intact ant nests inside experimental arenas, presenting each nest with two filter paper strips leading to identical food sources. We treated one strip with 2, 20, or 200 ant equivalents of synthetic 3-ethyl-2,5-dimethylpyrazine, the other with a solvent control. Two hours

later, we counted the number of ants on each food source. A trail of synthetic 3-ethyl-2,5-dimethylpyrazine significantly increased the ants foraging response in a dose-dependent manner. Synthetic trail pheromone could become part of integrated *M. rubra* control.

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Development of a food bait for European fire ants.

European fire ants (EFAs), *Myrmica rubra*, have become major pests in their invaded North American range where they seek a diverse diet. We tested the hypothesis that baits consisting of carbohydrates (e.g., apples) as well as lipids and proteins (e.g., deceased insects) are most attractive to foraging fire ants because this balanced-diet bait would meet all the ants' nutritional requirements. In large-arena experiments, baits consisting of both fresh apples and frozen mealworms (*Tenebrio molitor*) proved more attractive to foraging ants than baits consisting of either apples or mealworms alone. Prospective commercial ant baits ought to be cost-effective and storable in dry form to enhance their shelf life. Therefore, we tested the effects of (a) replacing mealworms with industrially-produced (cheap) house crickets (*Acheta domestica*) and (b) freeze-drying and rehydrating baits before bioassays. As bait constituents, mealworms and house crickets proved equally effective, and freeze-dried and rehydrated baits were nearly as attractive to foraging ants as fresh baits. In contrast, rehydrated baits consisting of commercially available tropical house cricket (*Gryllobates sigillatus*) powder and apple fruit powder proved significantly less attractive, possibly because key semiochemicals (message-bearing chemicals) were lacking in tropical house crickets or were lost during industrial food drying. The efficacy of freeze-dried and rehydrated baits consisting of apples and house crickets is currently being field-tested versus that of a commercial fire ant bait.

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New semiochemical lure and food and exciting baits for German cockroaches.

We designed and tested a new semiochemical lure and food bait for attracting German cockroaches (GCRs), *Blattella germanica*. In large-arena laboratory experiments, traps baited with rye bread captured 8-fold more GCR males than unbaited control traps. Headspace volatile extracts of rye bread attracted GCRs, prompting us to identify all odorants by gas chromatography-mass spectrometry. A 44-component synthetic blend of rye bread odorants, and other known bread odorants, was highly attractive to GCRs but the essential components in that blend are yet to be determined. Drawing on earlier findings that GCRs are attracted to (stale) beer, we predicted that an earlier step in the production of beer, where yeasts actively metabolize the sugar in malted barley powder (dry malt extract = DME), is even more attractive to GCRs. In laboratory experiments, a 3-component composition (3CC) comprising DME, water, and Brewer's yeast strongly attracted GCR nymphs, females, and males. Both Brewer's yeast and spoilage organisms in the DME or the water seemed to add to the attractiveness of the 3CC but there was no additive or synergistic effect between them.

The 3CC became optimally attractive to GCRs after 12 h of fermentation and stayed that attractive for at least 120 h. In field trapping experiments, the 3CC and - unexpectedly - also the DME each proved as effective for attracting and capturing GCRs as a commercial cockroach bait.

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Expanding the role of enteric bacteria in interspecific chemical communication in the black blow fly, *Phormia regina*.

The black blow fly, *Phormia regina*, is a cosmopolitan pest in both domestic and agricultural settings. As it has been associated with numerous pathogenic enteric bacteria, it is considered an important target for control efforts. *P. regina* lacks any aggregation, mating, or oviposition pheromones, and has been shown to rely on the swarming behavior of the bacteria *Proteus mirabilis*, a facultative symbiont inhabiting its digestive tract, to mediate intraspecific chemical communication. In this study, we isolated the bacteria *P. mirabilis*, *Serratia marcescens*, *Morganella morganii*, and two strains of *Exiguobacterium* spp. from food soiled by *P. regina* feeding activity, identifying them through DNA sequencing and MALDI-TOF-MS. In two-choice bioassays under lab conditions, *P. regina* demonstrated increased attraction to tryptic soy agar inoculated with either *P. mirabilis*, *S. marcescens*, or *M. morganii* when compared to a sterile control substrate. We also demonstrated this effect on beef liver and tofu, representing animal and plant-based protein substrates, respectively. These results are surprising, as neither *S. marcescens* nor *M. morganii* are swarming bacteria. Our findings thus help to expand the scope of the symbiotic relationship between *P. regina* and its gut symbionts, and may contribute to the development of new trap baits for *P. regina*.

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Volatile plant chemical lures to attract the parasitoid, *Apanteles polychrosidis*, to increase parasitism of *Caloptilia fraxinella*, on green ash in Edmonton, Alberta.

The use of biological control agents as an alternative to pesticides for control of horticultural pests is desirable in cities that follow an Integrated Pest Management approach. In Edmonton AB, *Apanteles polychrosidis* (Hymenoptera: Braconidae), a native parasitoid wasp, has shifted hosts to exploit the ash leaf-cone roller (ALCR), *Caloptilia fraxinella* (Lepidoptera: Gracillariidae), an introduced nuisance pest of horticultural ash (*Fraxinus*). As the primary parasitoid of ALCR, *A. polychrosidis* has the potential to be an effective biological control agent. We tested the use of synthetic semiochemical lures releasing the herbivore-induced plant volatile, methyl salicylate, and two green leaf volatiles ((Z) 3-hexenyl acetate, (Z) 3-hexanol), that are known to be detected by *A. polychrosidis*, to enhance parasitoid attraction to ALCR infested green ash trees, *Fraxinus pennsylvanica*. These lures were tested at a higher and lower release rate. The attraction of wasps was measured by capture on sticky traps, and

parasitism rate was measured by the presence of moth or wasp pupa in leaf rolls. More male and female wasps were captured in green ash trees baited with a combination of all plant volatiles tested as compared to control trees containing no lures. Parasitism of ALCR was not increased in trees baited with semiochemical lures of higher or lower release rate.

Elisabeth Hodgdon¹, Rebecca Hallett², Yolanda Chen¹

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Evaluation of candidate pheromone blends for mating disruption of swede midge (*Contarinia nasturtii*; Diptera: Cecidomyiidae).

Swede midge is an invasive galling fly that is causing serious economic losses of crucifers in Canada and the Northeastern United States. Effective management strategies for swede midge are limited. Use of the female pheromone, a mixture of three chiral diacetates, is effective for monitoring and has been shown to increase yields when used in a pheromone mating disruption (PMD) system in Europe. However, due to the chirality of the pheromone compounds, PMD using the natural pheromone blend is not economically feasible. The objective of our research is to test the abilities of lower cost racemic pheromone blends to confuse males in a PMD system, achieving trap shutdown, and to reduce crop damage in small field plots of broccoli. We used hanging bag dispensers to test pheromone blends containing three- or one-component blends of either the chiral or racemic compounds. We found that male pheromone trap counts were significantly lower in plots treated with the three-component chiral and racemic pheromone blends versus the control plots, indicating that pheromone treatments confused males. Trap shutdown did not occur in plots treated with single pheromone components. Despite trap shutdown, damage to broccoli in all pheromone-treated plots was not significantly different than in the untreated plots. In order to develop a successful PMD system, additional investigations are needed to determine where midges mate. When crucifers are grown in rotational systems, midges may mate after emerging in fields where their hosts were grown last year rather than within the current year's crop needing protection.

Matthew Muzzatti, Rebecca H. Hallett

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The development of pheromone-based action thresholds for management of swede midge, *Contarinia nasturtii* Kieffer (Diptera: Cecidomyiidae), in canola.

The current action threshold used for control of the swede midge (*Contarinia nasturtii* Kieffer) (Diptera: Cecidomyiidae) in canola (*Brassica napus* L.) is based on the recommended thresholds for cole crops. However, our research team hypothesizes that these are too conservative for use in canola. The objective of this research is to determine density effects of swede midge on canola growth and yield in a field-realistic situation. Lab and field cage trials of canola at the 2.5 growth stage exposed to different densities of swede midge representing various levels of infestation were completed. Damage ratings were made twice per week until canola reached maturity. Additional lab and field cage trials will be conducted with additional growth stages in

2018. These data will be used in combination with pheromone trapping and field damage data to develop the action threshold. It is critical to determine when swede midge populations warrant pest management efforts to minimize both insecticide costs and yield losses, and this project will provide valuable information towards the development of a comprehensive integrated pest management program within Canada for swede midge in canola.

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Monitoring wheat midge in the Peace River region: seasonal and diurnal flight patterns and comparison of commercially available pheromone traps.

The orange wheat blossom midge, *Sitodiplosis mosellana* Géhin (Diptera:

Cecidomyiidae) is an invasive pest on wheat (*Triticum* spp.) in all wheat growing

regions of Canada. The objective of this research is to assess the flight activity of and

develop monitoring tools for wheat midge in the most northern part of its expanded

range in the Peace River region of Alberta. Daily flight activity was assessed with in-

field counts of adult midge in commercial wheat fields on calm nights during peak

flight. Season-long flight activity was monitored with pheromone-baited traps. We

compared trap capture of male midge in green and orange delta traps baited with

pheromone released from flex lures (Scott's), or rubber septa lures (Scott's or Great

Lakes IPM Inc.) to that in unbaited control traps. Traps were monitored weekly during

wheat midge flight. Diurnal flight activity peaked between 9:00 pm and midnight in

2016. In 2017, flight activity in the most northern location studied (Fort Vermillion

AB) peaked between 10:30 pm and midnight which was later than at other sites in the

Peace River region (Falher AB) where peak activity occurred between 9:00 and 10:00

pm in 2017. In 2016, significantly more wheat midge were captured in pheromone-

baited traps compared to unbaited traps, but there was no difference in the number of

midge attracted by the different lures tested. Seasonal activity peaks varied by four

weeks among sites. The results from this study will help us understand wheat midge

flight activity and develop monitoring tools for this pest within its relatively new

northern distribution.

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Bumble bee (*Bombus* spp.) bycatch in moth pheromone traps in canola and wheat fields of central Alberta, Canada.

Unintentional capture of hymenopteran pollinators, including bumble bees (*Bombus*

spp.), in pheromone-baited traps targeting moth pests occurs in many agro-ecosystems.

Capture of bumble bees may negatively impact biodiversity and pollination services in

crops, and reduce monitoring system efficiency. We conducted field experiments in

canola and wheat crops in central Alberta, Canada. Capture of bumble bees in green

Unitraps® baited with either a food-bait lure (1:1 ratio of fermentation products acetic

acid and 3-methyl-1-butanol) or with a pheromone lure of one of four different

cutworm moth pests (Lepidoptera: Noctuidae) was compared to capture in unbaited traps. Additional components (2-methyl-1-propanol, phenylacetaldehyde) were tested in combination with the food bait lure. More *Bombus* spp. were captured in traps in canola than in wheat. More species and a greater number of bumblebees were captured in pheromone-baited than unbaited traps. Traps baited with the food-bait lure captured a similar number of bumble bees as control traps. The addition of the floral volatile, phenylacetaldehyde, to food-bait lures increased capture, so that it was statistically similar to that in pheromone-baited traps. Morphometric measurements of the most commonly captured species, *Bombus rufocinctus*, showed that similarly sized *Bombus* spp. were captured in traps across all lure type and location combinations and provided limited evidence of queen bee capture in traps. Pheromone-baited traps are common and necessary components of many integrated pest management programs targeting moth pests. Removal of bees in these traps affirms the need for investigation into the mechanism of bumble bee attraction to noctuid pheromones.

14:30- 16:30 Monday

Regular Oral Presentations: Agriculture

Chandra Moffat

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Host plant traits and herbivore adaptation: rapid evolution in the context of insect pest management.

Modern agriculture has strongly influenced the ecology and evolution of herbivorous insects by both increasing resource availability and inflicting novel selective pressures. Crop domestication has selected for crop (host) phenotypes unlikely to occur in nature and generated widespread monocultures in un-exploited regions. The repeated application of insecticides has spurred rapid evolution of insect pests by selecting for insecticide-resistant populations. The Colorado potato beetle (*Leptinotarsa decemlineata* (Say), CPB) is a devastating defoliator of potato (*Solanum tuberosum*), infamous for its ability to rapidly evolve resistance to new insecticides. Yet less than 200 years ago, CPB was an innocuous leaf beetle, restricted to its natal hosts *Solanum angustifolium* and *S. rostratum* in the highlands of Mexico. A long held hypothesis is that CPB's propensity for rapid adaptation to novel compounds is rooted in its co-evolutionary history with the glycoalkaloid-rich *Solanum* species. In an effort to break reliance on synthetic insecticides, new hybrid-cultivars are in development that incorporate multiple traits of wild *Solanum* species (outside the ancestral host range of the CPB) into *S. tuberosum*. These crosses show a variety of intermediate phenotypes and a spectrum of resistance to CPB. But will contemporary populations of CPB, selected so strongly for adaptation to novel toxins, be able to rapidly evolve tolerance to hybrid cultivars? I will test this hypothesis through a series of experimental evolution studies and high through-put sequencing, using CPB populations with different micro-evolutionary histories. The results of this work will inform field-implementation of CPB-resistant hybrid cultivars and develop relevant IPM practices.

Martin Erlandson¹, Cathy Coutu¹, Jennifer Holowachuk¹, Tara Garipey², Owen Olfert¹, Dwayne Hegedus¹

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Examining population structure of bertha armyworm, *Mamestra configurata* (Lepidoptera: Noctuidae), in western North America during one outbreak cycle.

The bertha armyworm (BAW), *Mamestra configurata* Walker, is a major insect pest of canola in western Canada. The factors that drive the outbreak cycles of BAW populations are not well understood, particularly with respect to the conditions required for increases in populations at the beginning of an outbreak cycle. It is not known whether the expanding distributions of populations in progressive years of the outbreak cycle result from the migration of founding moth populations from epicentres of resurgence or result from a general increase in abundance of populations across its geographic range from one year to the next. Despite the importance of this pest insect, little is known about BAW biodiversity in terms of the genetic variation of geographic populations and no attempt has been made to determine if the genetic make-up of outbreak populations differs from those of populations at lower endemic abundance levels. Thus, we extensively sampled male BAW moths across their geographic range during the last outbreak (2011-2014) using pheromone traps. DNA samples from these male were used for CO1 haplotype analysis and the development of RADtag libraries for high throughput sequencing and SNP marker identification. To assist in the mapping of SNPs, a draft genome of BAW (581 Mb) was developed. Neither the CO1 haplotype analysis nor SNP marker assessment using STRUCTURE to examine genetic structure of BAW populations indicated the presence of significant diversity among geographic populations, thus supporting a single epicentre model.

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Where do migrants come from? Using naturally occurring stable isotopes to gain insight into seasonal migration of insects.

Currently there are no effective long-term strategies to manage insect outbreaks caused by migratory species. One major hurdle in developing such strategies is that for many species, we have no clear idea about the origin of immigrants. Do they originate from different places each year based on prevailing climatic conditions or do most come from a specific geographic region each year? For example, the true armyworm, *Pseudaletia unipuncta*, is a sporadic pest in eastern North America and management decisions for outbreaks are based on the pheromone and/or light trap catch data from late spring, which provide an intervention window of less than three weeks. We present the results of a pilot study undertaken to determine the feasibility of using stable isotopes of hydrogen ($\delta^2\text{H}$) to determine the origin of true armyworm adults captured during the three annual flight periods in London, Ontario in 2016. We will also examine how there are no effective long-term strategies to manage insect outbreaks caused by migratory species. We will also discuss how $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values may be used to identify more precisely the source of migrants.

Christine Nieman¹, Schaefer, D.M.¹, Düring, R.-A.², Heinrich, A.², Floate, K.D.³

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LongRange® (eprinomectin), faecal residues, and dung-breeding insects.

Endectocides (*e.g.*, doramectin, eprinomectin, ivermectin, moxidectin) are veterinary pharmaceuticals with a broad spectrum of efficacy against nematodes and arthropods. Regardless of the route of administration (*e.g.*, oral, injectable, pour-on, bolus), the dose is largely excreted, unaltered, in the dung of the treated animal. Varying with product, formulation and insect species, faecal residues can suppress insect activity in dung voided by cattle treated weeks or months previously. LongRange® is a new formulation of endectocide with a novel dual-phase technology designed to release eprinomectin into the blood of the treated animal over 150 days. The produce is applied as a single injection. Following application, levels of eprinomectin in blood plasma peak in the first few days followed by a second smaller peak at about Day 90. Based on this profile, we hypothesized that cattle treated with LongRange® would faecally-excrete residues of eprinomectin for at least 120 days at levels sufficient to reduce insect activity in their dung. The current study was undertaken to test this hypothesis and, to our knowledge, is the first study to report on the non-target effects of residues in dung from cattle treated with LongRange®.

Suzanne Blatt, Jeff Franklin

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A new look at cultivar preference in European apple sawfly, *Hoplocampa testudinea* (Klug).

Many insect species show a preference for certain cultivars within their host. This is often determined through assessment of damaged fruit or plant. The European apple sawfly, *Hoplocampa testudinea*, has shown a preference for apple cultivars in Nova Scotia, Canada and can be an economically important pest in eastern Canada. Original cultivar preference for *H. testudinea* was observed and assessed at harvest based upon number of fruit with primary, *i.e.*, superficial, damage. Closer examination of this species has determined that this is not accurate and can underestimate the full impact of this pest in apple orchards. Additionally, trees with high primary damage at harvest may be demonstrating an ability to withstand *H. testudinea* attack through decreased larval survival. As such, examination of the fruitlets throughout development can provide a more accurate indication of the impact of *H. testudinea* in apple. Fifteen commercial and experimental apple (*Malus pumila* Miller) cultivars were chosen and examined for *H. testudinea* oviposition and fruitlet survival followed by damage assessment at harvest. *Hoplocampa testudinea* showed a significant cultivar preference at oviposition, during fruitlet development and again at harvest. The ranking of these cultivars was not the same throughout the season. Chemical analysis, *e.g.*, acidity, firmness and Brix, of the fruitlets during development offers some insight into the potential mechanism for these differences. The true impact and cultivar preference of *H. testudinea* cannot be assessed at harvest as the majority of damaged fruitlets drop from the tree before harvest.

Julia Mlynarek, Roselyne Labbe

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Recording introduced species: the story of *Trialeurodes abutiloneus*.

Species are introduced into Canada on a regular basis. Certain species are not officially recorded and others may go unnoticed for many years. Such is the case of *Trialeurodes abutiloneus*, the banded-wing whitefly (BWFF). In 2016, it was identified on greenhouse grown soybeans in Southwestern Ontario. It has a broad geographical and wide host distribution. It is a congener of the common greenhouse pest, *Trialeurodes vaporariorum* and is usually found sympatrically with other whitefly species. But there is more to the story, BWFF has been present in Canada for a lot longer but never officially recorded and, luckily, has never become a pest as it is in the Southern United States. We will take through the history of BWFF in Canada, discuss potential reasons why this species has been overlooked, give examples of other species in the same predicament, contrast those that are being closely monitored, and make the case for why recording species is important.

9:30- 12:00 Tuesday

Regular Oral Presentations: Agriculture

Aditi Singh¹, Suresh Desai¹, Lisa Flaten¹, Tushar Upreti¹, Deirdre Khan¹, Chris Anderson², Jodi Beattie², Jim Baum², Michael Crawford², Mark Belmonte¹, Steve Whyard¹

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Controlling flea beetles on canola using insecticidal double-stranded RNA.

Canola (*Brassica napus*) is Canada's most important oilseed crop, covering approximately 20 million acres, with an estimated production of 18 million tonnes. The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze) and the striped flea beetle, *Phyllotreta striolata* (F.) are the most economically-important pests of canola in Canada, causing approximately \$250 million in losses annually. Broad-spectrum chemical insecticides are routinely used to control these pest insects, but with growing concerns about their negative impacts on non-target species, new, environmentally-safer insecticides are needed. Here, we describe our efforts to identify double-stranded RNAs (dsRNAs) that can selectively kill flea beetles through an RNA interference response, without adversely affecting non-target species. DsRNAs were topically-applied to canola leaf discs in different formulations to assess their effectiveness. Insects were fed dsRNAs ranging from 15 ng to 500 ng per leaf disc to identify those with insecticidal activity. Numerous dsRNAs were identified as highly effective in killing both species of flea beetles, with no obvious impacts on a non-target species. Quantitative RT-PCR confirmed significant knockdown of targeted mRNA levels in the beetles that consumed the dsRNA, and while significant mortality of the insects was not observed until day 7, leaf consumption was greatly reduced within just a few days of exposure to the dsRNA. The dsRNAs were remarkably persistent on canola leaves, which suggests that topical application of dsRNA could be a valuable control strategy for foliar feeding insect pests of canola.

Suresh Desai, Michael Becker, Aditi Singh, Tushar Upreti, Lisa Flaten, Mark Belmonte, Steve Whyard
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Sequencing, de novo assembly, and annotation of the canola flea beetles *Phyllotreta cruciferae* and *Phyllotreta striolata* transcriptomes.

The crucifer flea beetle, *Phyllotreta cruciferae* (Goeze), and striped flea beetle, *Phyllotreta striolata* (Fabricius), are the most prevalent pests of canola in Canada. Adult flea beetles feed on canola seedlings in early spring, greatly diminishing crop yields. Economic losses due to flea beetle attack are estimated at \$250 million annually. Additionally, Canadian growers spend \$30 million on flea beetle control, which includes the use of broad-spectrum insecticides with off-target effects. This study aims to develop RNAi-based technologies that can mitigate flea beetle damage. To identify targets for RNAi knockdown, we sequenced the transcriptomes of both flea beetle species at the adult (male and female) and larval growth stages. In total, six individual transcriptomes were assembled and annotated, with many transcripts showing similarity to those of other beetle species. We identified transcripts unique or shared across assembled transcriptomes with fuzzy k-means clustering, allowing selection of species- and stage-specific targets. Further, we identified a suite of RNA-related transcripts, such as RISC complex constituents, anti-viral RNAi and dsRNA uptake, and dsRNA processing. This assembly and annotation of the transcriptome of *P. cruciferae* and *P. striolata* offers new insights into functional RNAi associated genes. Comparison of *Phyllotreta* transcript sequences with those from other insects has also enabled us to identify potential target genes for RNAi-mediated flea beetle-specific control strategies. We intend to use the transcriptomic information to develop new strategies that selectively control these key pests, without adversely affecting non-target species in the canola agriculture ecosystem.

Tharshinidevy Nagalingam¹, Héctor A. Cárcamo², Tyler Wist³, Jennifer Otani⁴, John Gavloski⁵, Rob W. Duncan⁶, Alejandro C. Costamagna¹

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Economic threshold for flea beetles in canola in the Canadian Prairies.

Flea beetles are one of the major pests in canola. To manage flea beetles, farmers rely on insecticide-treated seeds, complemented with foliar insecticide applications when required. A nominal threshold currently utilized for foliar applications is 25% defoliation, and this is based on conventional canola varieties. From 2015 to 2017, we conducted small plot trials to validate the economic threshold using current hybrid cultivars in Alberta, Saskatchewan, and Manitoba. The treatments included an unsprayed control, a neonicotinoid-treated seed with no foliar insecticide spray, and foliar insecticide sprays at 15-20%, 25%, and 45% defoliation levels. We assessed defoliation by flea beetles, canola phenology, flea beetle abundance, and seedling

survival. When the average defoliation of a sprayed treatment reached its threshold, the plots were sprayed with Matador (lambda-cyhalothrin) at 34 mL/ac, within 24 h of the assessment. At harvest, seed yield and seed quality were determined. Results from the initial two years of experiments suggest that the neonicotinoid seed treatment produced the highest numerical yield. Applying foliar insecticide provided yield protection compared to the treatments without any seed treatment or foliar insecticide. In some trials, foliar insecticide did not maintain yield at the same level as the seed treatment. Our preliminary analyses suggest that the threshold of 25 % defoliation appears valid. Detailed analysis of these results, including plant density and defoliation levels in plots, will be discussed.

Boyd Mori¹, Bradley Sinclair²

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Discovery of a new *Contarinia* species creating flower galls on canola in the Canadian Prairies.

A new species of *Contarinia rondani* (Diptera: Cecidomyiidae) was found creating canola (*Brassica napus*) flower galls in Saskatchewan and Alberta, Canada. Canola flower galls have been observed on the Prairies since 2012 and were attributed to the swede midge, *Contarinia nasturtii* (Kieffer). Subsequent investigations revealed that the causative agent was another, as of yet, undescribed *Contarinia* sp. Here, we describe the species, its biology, known range and pest status. We present behavioural, morphological, and genetic evidence that clearly indicates differences between the *Contarinia* sp. collected in Saskatchewan and Alberta and the swede midge.

Crystal Almdal, Alejandro C. Costamagna

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Determining the role of crop and non-crop habitats in providing sustainable aphid suppression in soybeans in Manitoba.

The soybean aphid, *Aphis glycines* Matsumura, is a major pest of soybean in North America. Currently, pesticides are the primary method used to control soybean aphids. Natural enemies have been found to significantly reduce soybean aphid populations in various regions of North America, including Manitoba. The importance of adjacent crop and non-crop habitats in enhancing pest suppression by natural enemies is not fully understood. The objective of this study was to identify what adjacent crop and non-crop habitats support natural enemies of soybean aphids, to quantify their movements between habitats and to test their impacts on aphid suppression. Based on previous results, we hypothesize that soybean neighboring cereal crops, alfalfa, or natural vegetation will have greater soybean aphid suppression than soybean neighboring canola. We will present the results of aphid and natural enemy sampling and predator manipulation experiments conducted in 12 soybean fields neighbouring either canola, wheat, natural vegetation, or alfalfa for a two-week period at the end of July (2017).

Annabelle Firlej¹, G. Lanouette¹, J. Brodeur², F. Fournier³, V. Martel⁴, M. Vreysen⁵, C. Caceres⁵

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Recent advances in the development of the sterile insect technique for *Drosophila suzukii*.

The spotted wing drosophila, *Drosophila suzukii* (Matsumura), has recently invaded Europe and North America. This pest has a devastating effect on small fruit crops as it attacks a large variety of ripening fruits such as cherries, raspberries, strawberries, blueberries. Control of *D. suzukii* populations has essentially been based on applications of broad-spectrum insecticides. We conducted study to explore the potential of sterile insect technique (SIT) as a control method for the spotted wing drosophila, first by irradiating pupae at different doses to identify the optimum dose for male sterilization, and secondly by evaluating the reproductive capacities of these irradiated males. First, it was observed that irradiation had no significant effect on emergence, malformation and longevity of adults at any of the doses tested. Two equations were obtained to link a given irradiation dose to a hatching rate of the eggs produced and to their survival rate to the adult stage. These results made it possible to choose the dose of 120 Gy for the continuation of the experiments. The reproductive capacities of males irradiated at this dose were therefore compared with those of non-irradiated males. Irradiated males were shown to be as effective as non-irradiated males to mate and transfer sperm to females in non-competitive conditions. In competitive conditions; however, the success of irradiated males against non-irradiated was of 37.5%. Then, an experiment on the re-mating of the females concluded that it was infrequent and was not influenced by the irradiation of the males.

Steve Whyard, Carlos Cruz, Alison Tayler, David Giesbrecht, Roohollah Abbasi, David Boguski, Aditi Singh, Cassidy Erdelyan

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Enhanced sterile insect technique using RNA interference technologies.

The sterile insect technique (SIT) is a biological control method that can reduce pest insect populations by releasing a large number of sterile males to compete with wild males for female mates to reduce progeny production. Typically, males are sterilized using radiation, but such methods can reduce their mating competitiveness. The method is most effective if only males are produced, but this requires the development of effective sex-sorting methods. We are developing non-transgenic, non-radiation methods of generating fit sterile male insects that efficiently mate with females, preventing the production of offspring. Currently, we are focussing on applying these technologies to both a disease vector mosquito, *Aedes aegypti*, and a tephritid pest of horticulture, *Bactrocera tryoni*. Larvae of both species can be fed double-stranded RNAs (dsRNAs) that induce an RNA interference (RNAi) mediated knockdown of both male fertility genes and female-specific genes to generate a male-biased sterile

adult population, which overcomes the need to sex-sort insects before release. Variability in the efficacy of RNAi in the insects has been observed, and hence, we are developing dsRNA microcarriers that enhance the uptake and systemic spread of dsRNA within the insects, to maximize the efficacy of the RNAi in these insects amenable to RNAi-mediated SIT. The sequence-specific gene-silencing mechanism of this RNAi technology renders it adaptable for species-specific application across numerous insect species. If consistent and potent male sterility and sex-sorting can be achieved using this technology, we envisage its use for traditional large-scale reared releases of mosquitoes and other pest insects.

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Clathrin-mediated endocytosis plays a key role in cellular uptake of dsRNA in mosquitoes.

RNA interference (RNAi) is a double-stranded RNA (dsRNA)-mediated method of silencing a genes expression, and is often used to study gene functions in model and non-model organisms. When many invertebrates are fed dsRNA, the dsRNA can enter the gut cells and can then spread throughout the organism to induce systemic RNAi. DsRNA transporters such as SID-1 can play an important role in cellular dsRNA uptake, but in dipteran insects, no SID-1 orthologues have been found. In this study, we examined the role endocytotic pathways to take in dsRNA in mosquito cells. Cultured *Aedes aegypti* cells were treated with a variety of chemical inhibitors of endocytosis, and then exposed to dsRNA targeting alpha-tubulin, to assess impacts on RNAi efficiency. Cells treated with selective inhibitors of clathrin-mediated endocytosis (CME), bafilomycin-A1 (BafA), and chlorpromazine (CPZ), showed marked reduction in RNAi efficiency, while cells treated with cytochalasin-D (CCD) and methyl- β -cyclodextrin (M β CD), inhibitors of phagocytosis-macropinocytosis and caveolae-dependent endocytosis, respectively, showed no impact on RNAi efficiency. The importance of CME for dsRNA uptake was further confirmed using an RNAi-of-RNAi technique, whereby RNAi was first used to knock down genes associated with CME, followed by a second exposure of a reporter gene-specific dsRNA to assess subsequent RNAi efficiency. Knockdown of Ap50, Chc, Rab7, Vha16 and VhaSFD all resulted in decreased dsRNA uptake. The importance of CME in dsRNA uptake and the potential for resistance to RNAi in mosquitoes will be discussed.

14:30- 17:15 Tuesday

Regular Oral Presentations: Agriculture

Julie-Éléonore Maisonhaute¹ Geneviève Labrie², Éric Lucas¹

¹Département des sciences biologiques, Université du Québec à Montréal, Montréal, QC; ²Centre de recherche sur les grains, Saint-Mathieu-de-Beloeil, QC;
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Integrated pest management of swede midge in the province of Quebec.

The invasive swede midge, *Contarinia nasturtii* (Diptera: Cecidomyiidae), was first observed in Canada in 2000 in Ontario. It invaded Quebec in 2001, with observations

made in vegetable crops, and was first observed in canola fields in 2006. Since then, great increases in populations have been observed, and important yield losses have been reported in some fields. The main objective of this project was to implement an integrated pest management of the swede midge in canola fields in Quebec. The first part of this project was to determine the best timing for application of two approved insecticides against the swede midge (Matador® = lambda-cyhalothrin and Coragen® = chlorantraniliprole), while the second part was to evaluate the natural control by parasitoids. Third, we also evaluated swede midge populations in wild Brassicaceae in field margins. Canola fields were sampled in 2016 and 2017 in Témiscamingue (Quebec). Swede midge abundances varied greatly between years, sites, canola varieties and seed coating, with population peaks of 18-107 swede midges/trap/day. Results of the insecticide treatments also varied between years and sites, which makes it difficult to determine the best treatment. In both years, swede midge parasitoids were collected, but in late season only (after the two first population peaks). Interestingly, swede midges were collected on some wild plants in field margins (field pennycress, wild mustard). Overall, further analyses are required to understand completely the population dynamics of the swede midge in Quebec and to determine the best method of control.

Julien Saguez, Geneviève Labrie, Mathieu Neau, Annie Christine Boucher, Isabelle Fréchette

Centre de recherche sur les grains, inc., Saint-Mathieu-de-Beloeil, QC;
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Insect monitoring in Quebec field crops: a review of summer 2017.

In 2017, several projects were conducted in different field crops (maize, soybean, wheat and canola) located in Quebec. Different kinds of traps were used to monitor insect pests, including notably soil insects and different moths (the black cutworm, *Agrotis ipsilon*, the western bean cutworm, *Striacosta albicosta*, and the armyworm, *Mythimna unipuncta*). Agronomists and researchers who constitute the pest monitoring network in Quebec also follow other pests, among which soybean aphids (*Aphis glycines*), swede midge (*Contarinia nasturtii*) and orange blossom wheat midge (*Sitodiplosis mosellana* Gehin). The different scouting and trapping methods used to collect insect pests and the preliminary results obtained in 2017 in Quebec will be presented. The perspectives that could be developed in the next years will also be discussed.

John Gavloski

Manitoba Agriculture, Carman, MB; john.gavloski@gov.mb.ca

Insects on crops in Manitoba in 2017: an extension update.

Flea beetles (*Phyllotreta* spp.) were a concern on canola in the spring and early-summer, in spite of most canola seed containing a neonicotinoid seed treatment for early-season protection from flea beetles. Cutworms (Noctuidae) were also an early-season concern in some fields. Feeding from larvae of alfalfa weevil (*Hypera postica*) caused a lot of damage in some alfalfa fields from mid-June through the first 2 weeks of July. Thistle caterpillar (*Vanessa cardui*) was quite noticeable in many soybean and sunflower fields, and caused a lot of concern. Aphids (Aphididae) were at economic levels in several crops, including small grain cereals, peas, and soybeans.

Diamondback moth (*Plutella xylostella*) was at economic levels in some canola fields, in spite of quite low levels of adult moths in pheromone-baited traps early in the season in some of the affected areas. High levels of bertha armyworm (*Mamestra configurata*) were present in some canola fields in western Manitoba.

Lindsey Goudis, Jessica Rush, Joseph Stout, Wayne Barton, Scott MacDonald
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Inscalis insecticide: a novel insecticide for management of piercing-sucking pests.

Inscalis insecticide is an innovation from BASF for control of piercing-sucking pests across a broad range of crops. Representing a unique chemical class, this new insecticide offers a resistance management option for control of devastating insects such as aphids, whiteflies, and certain leafhoppers, psyllids, and scales. A favorable environmental profile, control of pests resistant to other insecticides, and low acute toxicity to pollinators and beneficial arthropods are a few of the key benefits of Inscalis insecticide. These features highlight the value of this new insecticide within resistance management and integrated pest management programs.

Swaroop Kher, Daniel Itenfisu, Scott Meers

Alberta Agriculture and Forestry, Brooks, AB; swaroop.kher@gov.ab.ca

Seasonal phenology of wheat midge and alfalfa weevil in Alberta with respect to near-real time weather parameters.

Management of insect pests is challenging, and effective implementation of pest management tactics requires accurate knowledge of the timing of pest occurrence. Weather-based insect pest forecasting systems can provide critical inputs to farmers on potential pest infestations and assist in timely pest management. Traditional predictive pest management models have relied mainly on the use of growing degree-days. There is scope to develop predictive pest phenology models to incorporate tritrophic interactions among crop hosts, insect pests and their natural enemies with respect to host crops. We studied weather-dependent development of two economically important pest species in Alberta namely, wheat midge, *Sitodiplosis mosellana* (Gehin) and alfalfa weevil, *Hypera postica* L., and discuss here preliminary findings of our predictive pest phenology models. We developed and deployed on-farm weather monitoring systems to collect NRT weather data in the commercial fields of alfalfa and spring wheat across Alberta. On these sites, weekly data on the development of the target insect pests and their principal natural enemies were collected with respect to crop growth stages. We observed variation in seasonal developmental patterns of both pest species across sites and years. Temperature, precipitation and relative humidity influenced adult emergence and timing of larval activity for both species. Significant variation in on-site weather parameters and pest development was observed between irrigated and dryland sites. Parasitoid emergence was synchronous with pest species. The results have implications for developing operational predictive models for these pest species in Alberta.

Tyler Wist¹, John Gavloski², Erl Svendsen¹

¹Agriculture and Agri-Food Canada, Saskatoon, SK; ²Manitoba Agriculture, Carman, MB; Tyler.Wist@agr.gc.ca

The Cereal Aphid Manager smart phone app: implementing a dynamic action threshold to help producers manage cereal aphids in their crops.

Aphid populations can increase rapidly and exceed economic thresholds resulting in yield loss in cereal crops. Aphid natural enemies however, have the capacity to keep aphid populations from reaching economic thresholds. A model that incorporates the life history of predators and aphids was constructed to predict population growth of aphids that incorporates the predation of the natural enemies identified previously in cereal field surveys. The model uses a dynamic action threshold (DAT) and will recommend an insecticidal treatment if the economic threshold will be exceeded or no treatment but continued monitoring if existing predators will control population growth. Included in the app are three species of cereal aphids and common natural enemies from the families Anthocoridae, Aphidiidae, Aphelinidae, Coccinellidae, Chrysopidae, and Nabidae. Details about the smartphone app (on iOS and Android platforms) and results of the beta testing from the 2017 field season will be discussed.

Ian MacRae, Timothy Baker, Nicole Dudycha, Robert Koch
Department of Entomology, University of Minnesota, Saint Paul, Minnesota, USA;
Imacrae@umn.edu

Models for estimating defoliation in cropping systems.

Rates of defoliation are used as action thresholds for controlling insects in many cropping systems. Such thresholds, however, require extensive scouting effort, are based only on a number of sampled points within the management area and are qualitative estimates, making them subject to individual bias. We will discuss a method of utilizing aerial imagery to accurately estimate whole field levels of defoliation, facilitating rapid and accurate treatment decisions.

Genevieve Labrie, Alexis Latraverse, **Julien Saguez**
Centre de recherche sur les grains Inc., Saint-Mathieu-de-Beloeil, QC;
genevieve.labrie@cerom.qc.ca

VFF QC: a new tool to determine the risk assessment of wireworms in Quebec field crops

Insecticide seed treatments are widely used in Quebec crop fields to manage soil insect pests, especially wireworms that constitute the main pests collected in bait traps. The most abundant species in Quebec was *Hypnoidus abbreviatus* (Say), which represented ca. 73% of all specimens. However, high population levels (> 3 wireworms/bait trap) were only found in 4% of the 778 sites monitored between 2011 and 2016. New legislation in the province and eventual restriction of neonicotinoid use in Canada generate the need to determine in which fields wireworms could represent a risk of damage. Because it is not conceivable to monitor wireworms by bait traps in all Quebec fields, the objective of this project was to develop and provide a decision tool, available online, for producers and agronomists that could help them to evaluate the risk to find high populations of wireworms in their fields and to choose the better method to adopt to manage wireworm populations. The huge data set (including agronomic, environmental and landscape parameters, wireworm populations) obtained

from the 778 sites monitored, allowed the identification of the most representative parameters explaining the occurrence and abundance of wireworms. Boosted regression tree analyses were conducted to develop a model in R software that calculates the risk assessment. This model is included into an interactive platform (Info-sols.ca) available on the web and that helps to select the fields and to record the results of the risk assessment evaluation. This tool, named VFF QC is freely available from the website: <http://cerom.qc.ca/vffqc>.

Wim van Herk, Bob Vernon

Agriculture and Agri-Food Canada, Agassiz, BC; wgvanherk@hotmail.com

Trap-based estimates of click beetle populations can vary depending on duration of trap placement.

In areas where wireworms are causing extensive damage to field crops (e.g., in PEI), pheromone traps can be used to determine click beetle population size and when to apply control measures. For trap-based estimates to be reliable, it is important to know how representative the catches are of the actual beetle population present. Since most pest click beetle species disperse primarily by walking, it is possible that keeping a pheromone trap in a permanent location causes the population immediately around it to be depleted. This would lead to underestimates of the actual population in the field. In this talk, we demonstrate that this can occur and that it can vary among species.

14:30- 17:00 Monday

Regular Oral Presentations: Ecology and Systematics

Patrice Bouchard¹, Yves Bousquet¹, Adam J. Brunke¹, Anthony Davies¹, Hume Douglas¹, Andrew B. Smith², Juliana Manoogian³

¹Agriculture and Agri-Food Canada, Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON; ²Canadian Museum of Nature, Ottawa, ON; ³University of Ottawa, Ottawa, ON; patrice.bouchard@agr.gc.ca

150 years of new beetles (Insecta: Coleoptera) described in *The Canadian Entomologist* (1868-2018) and associated publications.

A synthesis of the beetles described as new in *The Canadian Entomologist* (TCE), *The Canadian Entomologist Supplements* and the *Memoirs of the Entomological Society of Canada* will be presented. This summary will cover the more than 2000 new species-, genus- and family-group names proposed, where these new taxa originated and who described them. This presentation is intended to celebrate the significant taxonomic contributions made over the last 150 years in *The Canadian Entomologist* and associated publications.

Hume Douglas¹, Anthony Cognato², Vasily Grebennikov³, Karine Savard¹

¹Agriculture and Agri-Food Canada, Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON; ²Department of Entomology, Michigan State University, East Lansing, Michigan, USA; ³Canadian Food Inspection Agency, Ottawa, ON; hume.douglas@canada.ca

A matrix key to the *Ips* bark beetles of the World (Coleoptera: Curculionidae: Scolytinae).

Identification of *Ips*, especially from trade interceptions remains difficult because identification keys are limited to particular world regions. Digital interactive keys offer an efficient and versatile route to diagnostics that also capture intersexual variation. We coded more than 52 species level taxa of world Ipini into a matrix-based identification tool using both readily-observed and hidden characters. We made further refinements during the testing stage to avoid common sources of identification failure. The richly illustrated key, on a LUCID platform, offers quick reliable identification of *Ips* specimens. We find that this tool is often more rapid and user-friendly than existing dichotomous keys because users have more choice of characters.

Sophie Cardinal

Agriculture and Agri-Food Canada, Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON; sophie.cardinal@agr.gc.ca

Bee (Hymenoptera: Apoidea: Anthophila) diversity through time.

Bees are a diverse, worldwide group of ecologically and economically important pollinators. Not only are bees diverse in number, they are also highly variable in appearance and behaviour. This present diversity has evolved over the past ~125 million years throughout all major terrestrial biomes and has led to our present reliance on the pollination services provided by bees for much of the food we eat. I shall focus mainly on the diversification of bees through time, and discuss which lineages are more species rich or poor relative to their age, as well as where and when bees experienced shifts in their diversification rates.

Jeffrey Marcus

Department of Biological Sciences, University of Manitoba, Winnipeg, MB; marcus@cc.umanitoba.ca

My love-hate relationship with DNA barcodes, the Y2K problem, and the search for something better.

DNA barcodes are indisputably useful for rapidly identifying many species of organism. In many cases, DNA barcodes also provide insights regarding the phylogeny of organisms. However, the short stretches of DNA that make up barcodes fail to correctly discriminate between species in about 30% of cases. In addition, there are instances when phylogenies generated from barcode sequences are demonstrably incorrect. These barcode-based phylogenies frequently do not correctly reconstruct the evolutionary history of the mitochondrial genome, let alone the evolutionary history of the organisms. There are two causes for this phenomenon. First, the Cytochrome oxidase I (COI) gene used for animal DNA barcoding is the most highly evolutionarily constrained coding sequence in the mitochondrial genome. A consequence of this is that the variable sites in COI that can change without negative fitness consequences reach saturation more quickly than other parts of the mitochondrial genome, causing phylogenetic ambiguity among distantly related organisms. Second, because DNA barcode sequences are short, the number of variable sites is very small, causing phylogenetic ambiguity especially among closely related organisms. This is a biological analogue of the Y2K problem in computer science: the ambiguity that arises when legacy identifiers contain insufficient information for new demands being placed on an information storage and retrieval system. Using some examples from my own research program, I will present some alternatives to the current conventional barcodes

that will help resolves these issues, while maintaining much of the convenience and low-cost of conventional barcode approaches.

Zoe Lindo

Department of Biology, Western University, London, ON; zlindo@uwo.ca

Community downsizing of soil invertebrates in a warmer world.

Many climate predictions (increasing temperature, elevated CO₂ conditions) are anticipated to act as an enrichment scenario similar to nutrient additions for ecological communities, increasing metabolic rates of organisms and ecological process rates (e.g., decomposition). In an experimental study using 100 intact boreal peat land mesocosms, warming, elevated CO₂, and altered water table lead to shifts in plant, soil invertebrate, and fungal communities with cascading effects on decomposition and carbon flux. Warming was the main driver of these community compositional shifts. Specifically, warming altered soil invertebrate (Acari: Oribatida) communities in a way that lead to community downsizing the systematic proportional increase in smaller bodied organisms under climate change. Increases in smaller-bodied, non-sexually reproducing species was due to enhanced reproduction in small-bodied species, and there was no evidence of increased extinction rates for large-bodied predators. The increased prevalence of smaller-bodied species under warmer conditions (community downsizing) is hypothesized as an ecologically critical consequence of climate change, leading to changes in trophic transfer efficiency, and rates of nutrient and energy flux within ecosystems. However, the overall consequences of warming-induced changes in soil systems on ecosystem function are still unclear. As body size is intricately linked to metabolism, observed community downsizing of soil invertebrates suggests a reduction in soil food web trophic transfer efficiency with consequences for nutrient and energy dynamics. Examination of community body size spectra to observe community downsizing may be a powerful tool for understanding and predicting the consequences of global change.

Carlos Barreto, Zoë Lindo

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Do decomposer and decomposition dynamics across a hummock-hollow topology differ in boreal peat lands?

In boreal peat lands, low decomposition rate is the underlying cause of carbon sequestration. Decomposition of litter can be affected by micro-topographic factors relating to soil moisture and temperature, the quality of the plant litter, and by the biotic decomposer community. Exploring how these drivers of decomposition interact will give us a better understanding of carbon dynamics in boreal peat lands. I measured the decomposition (mass loss) of three common peat land plant functional types (*Sphagnum* moss, *Carex* sedge, *Chamaedaphne* shrub), and the micro arthropod communities associated with decomposition using litterbags placed in hollows (wet depressions) and hummocks (dry, raised areas) of a boreal peatland near White River, Ontario. Decomposition was significantly different between all plant litter types, and greatest in *Carex*, followed by *Chamaedaphne* and *Sphagnum* litters. Decomposition rates were not significantly different between hummock and hollow microhabitats. The decomposer community, however, displayed the opposite pattern being significantly affected by microhabitat, where richness and abundance of micro-arthropods were

greater in wet hollows than dry hummocks. Overall, 20 oribatid mite species were identified, 10 of which were unique to hollows and two to hummocks. Taken together, these results suggest that abiotic environmental conditions are the main drivers of community structure for decomposers, while plant litter quality is a bigger determinant of decomposition dynamics in boreal peat lands.

Victoria Nowell, Marla Schwarzfeld

Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, ON; Victoria.Nowell@agr.gc.ca

Systematics and diversity of Canadian Cunaxidae, a family of predatory soil mites.

Cunaxidae is a predatory family of soil and litter mites. Despite their abundance and potential for limiting pest arthropods, very few species of cunaxid have been recorded from Canada. However recent and historical collections indicate that a large number of mostly undescribed species are present. We are using molecular and morphological techniques to uncover the hidden diversity of this charismatic, raptorial family.

Mahmood Iranpour^{1,2}, Paul Hebert³, Antonia Dibernardo¹, Robbin Lindsay^{1,2}

¹National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, MB;

²Department of Entomology, University of Manitoba, Winnipeg, MB; ³Centre for Biodiversity Genomics, University of Guelph, Guelph, ON; mahmood.iranpour@phac-aspc.gc.ca

***Ochlerotatus ventrovittis* Dyar (Diptera: Culicidae): a new record for the mosquito fauna of Canada.**

As part of on-going mosquito surveillance activities at the National Microbiology Laboratory during the summers of 2012 to 2014, adult mosquitoes were collected using CDC light traps and sweep nets from selected localities in Manitoba, Saskatchewan, Alberta, and the Northwest Territories. Mosquitoes were identified, based on traditional morphological characters, using standard taxonomic identification keys and DNA was also extracted from selected samples. The DNA barcode region of the cytochrome c oxidase I (COI) gene was amplified using conventional PCR and PCR products were purified and sequenced. Results of morphological identification and COI sequence data confirmed the presence of small numbers of *Ochlerotatus ventrovittis* Dyar in several localities in each province and territory. This is the first report of this aedine mosquito from Canada, although it has been reported in the northwestern United States including Alaska. Details on the phylogenetic relationships among collected specimens will be discussed along with the biology, ecology and potential importance of *Och. ventrovittis* in the Canadian landscape.

9:30- 12:00 Tuesday

Regular Oral Presentations: Ecology and Systematics

Diana Robson¹, Cary Hamel², Rebekah Neufeld²

¹Manitoba Museum, Winnipeg, MB; ²Nature Conservancy of Canada, Winnipeg, MB
drobson@manitobamuseum.ca

Impact of grazing on pollination in Fescue Prairie.

In fescue prairie moderate cattle grazing can increase plant richness and diversity. However, whether these floristic alterations have a subsequent impact on the insect floral-visitors has not been extensively studied. We documented the plant and insect-visitor community at three sites with different cattle grazing histories. Overall, recently grazed plots had higher plant diversity than historically grazed and un-grazed ones but flower density, insect-visitor diversity, and insect visitation were not different. However, there were temporal variations within some months. Recently grazed plots had higher flowering stem density, and insect visitations in June but most of these factors were higher at un-grazed plots in late summer. These differences may be due to varying plant palatability, altered soil characteristics and changes in insect abundance (particularly of *Bombus* spp.) over the year. Thus cattle grazing could be considered both beneficial, for increasing floral resources in spring, and detrimental, for decreasing them in late summer. The best management strategy may be maintaining a mixture of moderately grazed and un-grazed land, as this would result in a steady supply of floral resources over the entire growing season.

Jess Vickruck, Paul Galpern

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Wetlands in intensively cultivated areas act as habitat reservoirs for native bee communities.

In intensively cultivated landscapes, habitats have been modified such that very little of the original habitat remains. The Canadian Prairies represent one such example of intensive agriculture, however many fields still have remnant wetland areas that have remained uncultivated. We investigated if these semi-natural features act as reservoirs for native pollinators in three distinct landscapes: canola, a mass-flowering crop, cereal, which provides no floral resources for bees, and native prairie landscapes that have never been cultivated. At each location, we collected bees at the margin of the wetland (0 m) as well as 25 m and 75 m in to the crop weekly across the growing season. Our results suggest that native bee abundance decreases from the wetland edge as you move into both canola and cereal fields, suggesting that wetlands act as point-source reservoirs for native pollinators in these landscapes. Native bee abundances did not decrease as trap locations moved further in to native prairie sites, suggesting that suitable habitat is available throughout the landscape and is not simply found near the wetland. Overall, trapping rate was also higher in cereal fields than canola fields, which may be due in part to the dilution effect of placing traps in a non-flowering vs mass flowering crop. Our results demonstrate that semi-natural features such as wetlands are important reservoir habitat for native pollinators in prairie landscapes.

Sarah Semmler

Living Prairie Museum, Winnipeg, MB; ssemmler@winnipeg.ca

Habitat and native pollinator conservation in the City of Winnipeg.

The conservation of native pollinators has become a part of habitat management in Winnipeg. The Living Prairie Museum (Naturalist Services Branch) has been working to better understand pollinator species richness in natural areas, particularly within tall grass prairie remnants. Base-line data has shown that these sites contain a diversity of native pollinating insects. An emphasis on prairie conservation, as well as restorations

and residential plantings using native plant species, is helping to ensure that pollinator communities have adequate refugia in an urban environment.

Alana Pindar, Nigel Raine

School of Environmental Sciences, University of Guelph, Guelph, ON;

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How much pollinator habitat is enough? Assessing optimal habitat requirements to support bee community composition in Ontario landscapes.

Habitat loss and fragmentation are among the most important factors contributing to pollinator declines. Although the importance of habitat quality and connectivity, as well as landscape composition and configuration, are comparatively well understood for wild bee communities, how much habitat is needed to sustain bee community diversity in landscapes remains unknown. Here, we use datasets from 32 bee surveys from agricultural and wild habitat collected over 25 years throughout southern Ontario to measure the amount of habitat needed to support bee community diversity at a range of foraging distances within the landscape. We investigate the importance of key habitat types in maintaining bee diversity and argue that preserving this diversity, not only total pollinator abundance, should be a management goal in order to conserve pollination services within landscapes.

Janet Sperling, Katharine Magor, Felix Sperling

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Bacteria associated with *Ixodes scapularis* (Acari: Ixodidae) ticks in Canada.

Ticks are important vectors of many diseases, not only Lyme disease. The blacklegged tick, *Ixodes scapularis* (Acari: Ixodidae), brings Canadians into contact with previously unrecognized pathogens as it expands its range. 16S amplicon microbiome studies are a first step in describing the bacteria associated with blacklegged ticks and can provide a broad overview of the regional variation in bacteria associated with these ticks. Sperling et al 2017 established that more than one region of the 16S marker gene is needed to accurately assess bacteria associated with ticks. We have now applied this technique to a greater number of specimens, which demonstrate considerable variation in bacterial composition east of the Rockies. The method is robust for detecting Lyme spirochetes as well as a great variety of taxonomically and ecologically diverse bacteria. Ticks from Alberta, Manitoba, Ontario and Quebec have a different assemblage of bacteria than those in Atlantic Canada. Western and central Canadian *I. scapularis* ticks are primarily associated with bacteria of the families Pseudomonadaceae, Enterobacteraceae and Rickettsiaceae, while Nova Scotia *I. scapularis* are associated with Rickettsiaceae or Pseudomonadaceae. Differences in bacterial assemblages may reflect competitive interactions or niche partitioning among different bacteria. Distinguishing among pathogenic and nonpathogenic bacteria that are likely to be carried by ticks is imperative in order to guide cost effective diagnostics and reduce burden on the health care system.

Steve Perlman, Matthew Ballinger

Department of Biology, University of Victoria, Victoria, BC; stevep@uvic.ca

Role of toxins in *Drosophila* defensive symbiosis.

Many insects harbour bacterial endosymbionts that provide protection against natural enemies, but little is known about the mechanism of protection. *Spiroplasma* bacteria infect a wide range of terrestrial arthropods and some strains that are symbionts of *Drosophila* flies protect them against parasitic nematodes and parasitic wasps. We found that the genomes of these defensive *Spiroplasma* contain a diverse repertoire of toxins called ribosome-inactivating proteins (RIPs), related to Shiga toxins of enterohemorrhagic *E. coli*. We present evidence implicating RIPs as major players in defense against both wasps and nematodes, and suggest that toxin diversity may be an important factor in shaping host- symbiont-enemy interactions.

Bindiya Sachdev, Daisuke Takahashi, Lisa Brummett, Michael Kanost

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Identification and quantitation of novel immune proteins in *Manduca sexta* (Lepidoptera: Sphingidae): a proteomics approach.

The tobacco hornworm, *Manduca sexta*, has been used extensively as a model for laboratory research in insect biochemistry, physiology, neurobiology, development, and immunity. This is mainly due to its large size, reaching more than 10 g in the larval stage, and now the *M. sexta* genome sequence increases the available approaches for molecular studies. Quantitative proteomics has been successfully applied to measure differentially regulated protein and peptide abundance. We describe here the use of ¹⁵N metabolic labeling to quantitatively compare the differential expression of hemolymph plasma proteins upon bacterial infection in *M. sexta*. Larvae were fed with tobacco plants grown in hydroponic setting with ¹³N (heavy) or ¹⁴N (light) as sole source of nitrogen. These insects were subsequently injected with a gram positive bacterium, *Micrococcus luteus*, or buffer as control, and hemolymph was collected 24 hrs post-infection. Reciprocal labeling was analyzed by combining the plasma from ¹⁴N-buffer control with ¹³N-bacteria injected insect and vice-versa. The mixtures were then separated by SDS-PAGE, gel segments were treated with trypsin, and resulting peptides were analyzed by mass spectrometry. Two datasets were generated from inverse labeling and searched against the *M. sexta* database for protein identification. The workflow was performed using Trans Proteomic Pipeline and quantitation software, Xpress. Differentially expressed immune inducible proteins such as anti-microbial peptides, pattern recognition receptors and proteinase inhibitors were identified and quantified. Several novel proteins strongly upregulated after infection were also identified, which are candidates as newly identified immune proteins. These results will be elaborated and discussed.

Paul Abram¹, Chandra Moffat²

¹AAFC, Agassiz Research and Development Centre, Agassiz, BC; ²Agriculture and Agri-Food Canada, Fredericton Research and Development Centre, Fredericton, NB; paul-abram@hotmail.com

Exploiting pace of life syndromes to breed better biological control agents.

Selective breeding techniques are routinely used in almost every area of agriculture to maximize desirable traits but not in biological control programs. Rather, within-species strains of arthropod natural enemies used in biological control are often chosen arbitrarily, by convenience, or based on single traits with tenuous links to biological control efficacy. Applying conventional breeding techniques could substantially enhance biological control efficacy by selecting for key traits in agent populations. A major challenge for developing such breeding programs is the identification of reliable indicators of forecasted performance that can be rapidly screened to select for desirable traits. Ideally, these performance indicators would be easy to measure but also correlated with a suite of physiological and behavioural traits that interact to determine biological control efficacy. Pace of life syndromes, where suites of physiological and behavioural traits coevolve to create within- and among-population intraspecific variation, provide a possible framework to identify these performance indicators and use them as tools in breeding programs for biological control agents. We propose overall behavioural activity level as a candidate performance indicator, and use it as a case study to discuss opportunities and caveats for using pace of life syndromes in selective breeding for enhanced biological control.

14:30- 16:30 Tuesday

Regular Oral Presentations: Forestry

Alex M Chubaty¹, Eliot J B McIntire¹, Barry J Cooke²

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Boreal insect disturbance in SpaDES: an integrated simulation model of mountain pine beetle eastward spread.

Mountain pine beetle (*Dendroctonus ponderosae* Hopk.; MPB) has spread beyond its native range in western Canada and its continued eastward spread threatens the boreal forests of Alberta, Saskatchewan, and beyond. Understanding MPB spread over the short, medium, and long terms requires modeling both the fast dynamics of invasive eruption, and the slow dynamics of forest and insect population collapse and forest regrowth. Recent spatial modeling results suggest that the most critical factors affecting invasive eruption dynamics are positive feedback processes occurring at low densities. The most critical threshold influencing MPB eruptive dynamics is the point at which populations in the endemic niche (comprised of suppressed trees) are willing and able to successfully mass attack trees in the epidemic niche (comprised of healthy, vigorous trees). We present ongoing work to develop a spatially explicit model of MPB nonlinear eruptive dynamics including dispersal and spatial variation in validated models of MPB climatic suitability. We describe the implementation of this predictive model in the western boreal forest using the SpaDES (Spatial Discrete Event Simulation) package for R. We show that variability in MPB spread rates and risk to boreal forest stands depends on which climatic suitability projections are used, and we evaluate the validity of these different climate suitability inputs. We further highlight the reusability of model components and their further integration across ecological domains via links with forest vegetation dynamics, fire, and other models implemented in SpaDES.

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How does synchrony with host plant affect the performance of an outbreaking insect defoliator?

Phenological mismatch has been proposed as a key mechanism by which climate change can increase the severity of insect outbreaks. Spruce budworm (*Choristoneura fumiferana*) is a serious defoliator of North American conifers that feeds on buds in the early spring. Black spruce (*Picea mariana*) has traditionally been considered a poor-quality host plant since its buds open later than those of the preferred host, balsam fir (*Abies balsamea*). We hypothesize that advancing black spruce budbreak phenology under a warmer climate would improve its phenological synchrony with budworm and hence increase both its suitability as a host plant and resulting defoliation damage. We evaluated the relationship between tree phenology and both budworm performance and tree defoliation by placing 7 cohorts of budworm larvae on black spruce and balsam fir branches at different lags with tree budburst. Our results show that on both host plants, spruce budworm survival and pupal mass decrease sharply when budbreak occurs prior to larval emergence. Emergence before budbreak decreases survival, but does not negatively impact growth or reproductive output. We also document phytochemical changes that occur as needles mature and define a window of opportunity for the budworm. Finally, larvae that emerged in synchrony with budbreak had the greatest defoliating effect on black spruce. Our results suggest that in the event of advanced black spruce phenology due to climate warming, this host species will support better budworm survival and suffer increased defoliation.

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Detection of exotic and potentially invasive bark- and wood-boring beetles can be improved by using pheromone-enhanced lures, and by installing traps in both the tree canopy and understory.

Bio-surveillance programs aimed at early detection of exotic bark- and wood-boring beetles often use traps baited with host plant volatiles that are installed in the forest understory. Recently, pheromones of several cerambycids have been identified and their parsimony and sensitivity suggest they have great potential for use in biosurveillance. Species composition of bark and wood-boring beetles caught in traps placed in the forest understory may be quite different that of the tree canopy. Here, we present the results of experiments evaluating the impact of trap height (understory vs. canopy) and lure type (standard UHR ethanol lures vs. pheromone-enhanced lures or a comparison of three different pheromone-enhanced lures) on the diversity and abundance of captured bark- and wood-boring beetles (*i.e.*, Buprestidae, Cerambycidae and Scolytinae). Using 12-Lindgren funnel traps, these 2x2 or 2x3 (trap height x lure

type) factorial experiments were conducted in mixed wood forests near industrial areas. Data on the mean number of species and specimens captured per trap, the probability of a trap detecting a given species, and sample-based rarefaction curves suggest that using pheromone-enhanced lures (or a combination of different pheromone-enhanced lures), and installing traps in both the tree canopy and understory will improve detection rates of exotic and potentially invasive bark and wood-boring beetles, and should be implemented into biosurveillance programs.

Maya Evenden¹, R. Batallas¹, D. Sjolie¹, D. Hoefele¹, P. Arachchige¹, C. Saran¹, B.A. Keddie¹, C.J.K. MacQuarrie²

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The sublethal effect of microsporidian infection on the flight capacity of the forest tent caterpillar, *Malacosoma disstria* (Lepidoptera: Lasiocampidae).

The forest tent caterpillar, *Malacosoma disstria* Hübner (Lepidoptera: Lasiocampidae) is a native forest defoliator with a broad geographic range in North America. *M. disstria* experience cyclical population changes and at high densities, repeated defoliation can cause reduced tree growth and tree mortality. Unicellular microsporidian parasites infect *M. disstria* in natural populations and infection level changes with population density. In the current study, we test the impact of sublethal microsporidian infection on the flight capacity of *M. disstria* moths using a flight mill bioassay. Following flight, the fat of each moth was extracted as a measure of energy use and wing loading (mg/mm²) was calculated for each experimental moth. The abdomen of each moth was ground in super water and the suspension was viewed microscopically to enumerate microsporidian spores. Sublethal infection with microsporidian parasites affects *M. disstria* flight as infected moths were less likely to fly than uninfected moths on the flight mills. Although infected male *M. disstria* have reduced wing loading compared to uninfected male moths, infection reduced the distance flown only in female *M. disstria*.

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Mountain pine beetle (*Dendroctonus ponderosae*) population structure and genomic architecture based on genotyping-by-sequencing.

Recent proliferation of sequencing technologies has generated a flood of data that is rigorously filtered before being applied to population structure assessments. We compared the standard procedure of filtering for Hardy-Weinberg equilibrium and linkage disequilibrium against an approach of first applying principle components analysis to detect linkage blocks. We used genotyping-by-sequencing technology to give genome-wide single nucleotide polymorphisms (SNPs) for a population survey of the mountain pine beetle (MPB; *Dendroctonus ponderosae*), a major forest pest. We found two cohorts of linked SNP markers, one that was sex-linked and offers a genetic method for sexing MPB samples, and one that is composed of various metabolic genes that may provide evidence of adaptive selection in northern populations. The remaining filtered SNPs replicated the same large-scale population structure

previously detected with other genetic markers; these SNPs provide a convenient array for more fine-grained landscape genomics analysis.

Amanda Roe, Krista Ryall, Greg Pohl, Yuehong Liu, Kyle Snape
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Delimitation dilemma - defining species limits in the bronze birch borer complex (*Agrilus anxius*).

Bronze birch borer (BBB - *Agrilus anxius* Gory) is a common, but infrequently collected pest of birch. BBB is recognized as a high risk invasive in Europe. Reliable diagnostics of BBB and its relatives are needed to provide effective biosurveillance of potential invasives in Europe. Morphological traits separating these species are variable and often host plant and locality are needed to separate the species. Molecular data show incongruence between genetic variation and established species limits, highlighting the need to revisit the taxonomy of this important group of forest pests.

9:30- 11:45 Wednesday

Regular Oral Presentations: Biocontrol

Bernard Roitberg¹, David Gillespie², Thomas Hoffmeister³

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Non-target impacts of biocontrol: twenty-six years later.

Despite all the attention to non-target impacts of biocontrol, there remain several significant issues. Here we address several key items including: (i) Host range assessment we consider various metrics in the context of the behavioural plasticity expressed by many biocontrol agents and the best approaches for analyzing host acceptance data; (ii) Effect size on non-targets here, we employ density-dependent population dynamics as a function of intra and interspecific interactions to evaluate population-level risk to non-target organisms; and (iii) Economic injury from attacks on non-targets here we introduce new methods to determine the economic risks (and benefits) from release of non-specific biocontrol agents. Our purpose is to move away from the simple dichotomies inherent in assessments of biological control agents.

M. Lukas Seehausen¹, Sandy Smith², Robert Bouchier³

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Does host plant quality influence diapause in *Hypena opulenta* (Lepidoptera: Erebidae)?

Dog strangling vine (DSV) *Vincetoxicum rossicum* (Apocynaceae) is an introduced invasive plant in North America that is now widely established in Ontario and Québec. The plant forms dense forest understory and old field monocultures that outcompete native vegetation and destroy habitats. The moth, *Hypena opulenta* (Lepidoptera: Erebidae), was approved in Canada for classical biological control against DSV in 2013. In its native habitat of the Ukraine, *H. opulenta* is possibly multivoltine and has a

facultative diapause in the pupal stage. The factors that control diapause induction are not well understood and are suspected to be some combination of host plant quality and photoperiod. We conducted an experiment to investigate these factors on diapause induction of *H. opulenta* under laboratory conditions. Larvae were reared for two generations on two different foliage qualities (based on foliage age) and two photoperiods, long (16L:8D) and short (12L:12D). Short photoperiod was by far the dominant factor inducing diapause. However, older foliage decreased the mean pupal development rate when compared to young foliage and induced diapause in some individuals reared under the long photoperiod. To complement laboratory studies, *H. opulenta* adults were released in field cages between mid- and late-June. After two months of development, no diapause was induced in any pupa originating from the first date of release, but 97-100% of pupae from the subsequent releases were in diapause. The results will inform rearing and facilitate timing of release for this classical biological control agent.

Robert Bouchier¹, Sandy Smith²

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Foliage-supplemented artificial diets for rearing *Hypena opulenta*, (Lepidoptera: Erebidiae) to facilitate implementation of biological control of dog strangling vine (swallow-worts).

Hypena opulenta is a multivoltine moth originating in eastern Europe that has been identified as a potential biological control agent for invasive dog-strangling vine (DSV) in North America. This insect was first released in Canada in 2013 and is now established at early release locations in Ontario. *Hypena opulenta* has at least two generations during the field season and overwinters as diapausing pupae. To facilitate mass rearing and release of this insect, we investigated the potential for using DSV-supplemented artificial diets. An artificial diet would enable rearing and stockpiling of diapausing *H. opulenta* pupae during winter, for release at the start of the field season. Using a commercial beet-army worm diet, supplemented with either four-week old or ten-week old dried DSV foliage, we were able to produce viable, ovipositing moths with a mean survivorship rate of 37%, in the first generation. We compared moth survivorship, pupal weights and development times using insects reared on DSV plants versus DSV diets. Pupal weights on plants versus diets were not significantly different. Development times were longer and survivorship was slightly lower for insects reared on ten-week old foliage diets compared to four-week foliage diets. Surprisingly, diapause rates when insects were reared on DSV supplemented diets were less than 5%, which was lower than expected and much lower than previous studies that assessed *Hypena opulenta* rearing on DSV.

Rosemarie De Clerck-Floate, Kevin Floate

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Evidence for *Wolbachia*-induced speciation in a gall-forming wasp?

Aulacidea pilosellae (Hymenoptera: Cynipidae) is a European species of gall-forming wasp being studied as a potential biological control agent for release into North America against multiple species of invasive hawkweeds (*Pilosella Vaillant*,

Asteraceae). Previous field and laboratory studies have identified populations that are either specific to *P. officinarum*, or that occur on a range of *Pilosella* spp. excluding *P. officinarum*. Molecular markers identified genetic differentiation between the two population types, but not sufficiently so to ascribe them to cryptic species. Thus, for now, they are considered biotypes; *i.e.*, Biotype 1 ex *P. officinarum*; Biotype 2 ex *Pilosella* spp. For the current study, we established laboratory colonies of the two biotypes of *A. pilosellae*, which confirmed European information that populations of Biotype 1 are multivoltine (facultative diapause) and parthenogenetic (no males), whereas populations of Biotype 2 are univoltine (obligate diapause) and bisexual. Next-generation sequencing of these colonies showed populations of Biotype 1 to be uniformly infected with *Wolbachia*. Populations of Biotype 2 comprised both *Wolbachia*-infected and uninfected individuals. *Wolbachia* are maternally-inherited bacteria that are common symbionts of diverse arthropod taxa and are known to induce parthenogenesis in other species of wasps. These collective results suggest that infections of *Wolbachia* have induced parthenogenesis in a subset of *A. pilosellae* populations to cause genetic divergence associated with differences in host range and voltinism. If so, these biotypes may be examples of symbiont-induced speciation.

Marilyn Light, Michael MacConaill

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Putting it all together: herbivores, hosts, and herbaria.

The iconic showy lady s slipper orchid, *Cypripedium reginae*, in Gatineau Park, QC is associated with an impressive assemblage of 17 species of insects including herbivorous leafminers, thrips, whitefly, caterpillars, and associated parasitoids and entomopathogens whose effectiveness is such that the orchid population is not at risk from these insects. Characteristic feeding damage, adhering egg shells, and the remains of leaf-mining larvae collected with herbarium specimens has been used to establish the incidence of infestations elsewhere and now forms the basis of vouchers being deposited with CAN: insect vouchers are deposited with CNC (Ottawa).

Jean Philippe Parent¹, Jacques Brodeur², Félix-Antoine Savard², Guy Boivin³

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Factors influencing walking speed in insects: not just a matter of size and age.

Locomotion is essential but energetically costly for most animals. Walking has received substantial attention in insects, yet the impact of body size and age on walking speed within species has been the topic of relatively few studies. The first objective of this study was to survey the literature to test the hypothesis that, within insect species, walking speed is proportional to size and inversely proportional to age. The second objective was to investigate these relationships in egg parasitoid species that use walking speed to evaluate host quality and where an impact of size or age on walking speed would induce a bias in the perception of resource quality. As predicted, within an insect species, walking speed generally increases with body size and decreases with age, with some exceptions. Walking speed was size-dependent for *Trichogramma pintoi* and *Trichogramma minutum*, but was found to be both size- and age-independent for *Trichogramma euproctidis*. These results suggest that general

patterns of walking speed observed in other taxa can be generalized for most insects. This relationship becomes less intuitive in species that use locomotion as a measuring tool (such as *T. euproctidis*), and may be selected to maintain walking speed constancy in the face of aging and phenotypic variation.

Rhoda deJonge¹, Sandy Smith¹, Robert Bourchier²

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Spillover of adventive insects from introduced *Phragmites* to a native subspecies.

The European common reed, *Phragmites australis* subsp. *australis*, is an invasive plant that is detrimental to North American wetlands causing reductions in floral and faunal diversity and altering nutrient cycling. This introduced grass outcompetes native vegetation, including the related North American subspecies, *P. australis* subsp. *americanus*. To date, 28 insect species have been reported from introduced common reed, of which 23 were accidental, introduced along with the plant. Apparent competition or the spillover of these adventive natural enemies from the introduced *Phragmites* subspecies may be one indirect way it is affecting the native *Phragmites* subspecies. To investigate the incidence of spillover in Northern latitudes on established field populations, we compared the diversity and number of insects found inside stems, on florets, and within roots of *Phragmites* at 14 sites throughout southern Ontario. Each site contained paired patches of native and non-native forms of *P. australis* for a total of 28 sample patches. We found that for the 12 most abundant insect species that were present throughout the sites, four were more common on the native North American subspecies than on their introduced ancestral European hosts. Thus, spillover seems to be occurring in southern Ontario and may be having a detrimental impact on the native sub-species of *Phragmites* in this region. More importantly, our survey suggests that some of the adventive insects prefer the native *Phragmites* subspecies over the introduced host plant. This is the first recorded incidence of a root-feeding larva (*Rhizedra lutosa*) feeding on *P. australis* subsp. *americanus*, and the first observation of *Chaetococcus phragmitis* on *Phragmites* in Canada.

8:30-9:30 Monday

President's Prize: Student Competition Posters Presentations

Asha Wijerathna¹, Harker, Neil², Héctor Cárcamo³, Maya Evenden¹, Patty Reid², Breanne Tidemann²

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The effects of seed and foliar insecticide treatments in controlling pea leaf weevil (Coleoptera: Curculionidae) damage on faba bean in Alberta.

The pea leaf weevil, *Sitona lineatus* L. (Coleoptera: Curculionidae), is an invasive pest of field pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.), that is well established in southern Alberta and southwestern Saskatchewan. Recently, pea leaf weevil has caused visible and persistent damage to these crops and particularly to faba beans in south

central Alberta. In this study, we test the potential to manage pea leaf weevil using seed (thiamethoxam) and foliar (cyhalothrin-lambda) insecticides registered in this crop for other pests. The effect of pea leaf weevil feeding on faba bean plants with no insecticide treatment is compared to that on plants treated with insecticide seed treatment, with foliar insecticide sprayed at the 2nd node stage and those treated with foliar insecticide at the 2nd and 4th node stages. The field trials were repeated in 2016 and 2017 near Lethbridge and Lacombe, AB. Data on adult feeding were collected before and after the application of foliar insecticides and root nodule data were collected at early flower and early pod stages. Results on adult feeding notches, root nodule characters and yield of the variously treated faba bean plants will be presented. Findings from this study will highlight the efficacy of seed and foliar insecticides in managing pea leaf weevil on faba bean and will be useful in determining an action threshold for pea leaf weevil on faba bean.

Megan Stevenson¹, Kim Hiltz¹, N. Kirk Hillier², Suzanne Blatt¹

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Efficacy of entomopathogenic nematodes as a pest management strategy against *Listronotus oregonensis*.

Four entomopathogenic nematodes products were evaluated to control carrot weevil (*Listronotus oregonensis*) in Nova Scotia. *Steinernema* System, *Carpocapsae* System, *Kraussei* System, and B-Green Sytem nematode products (BioBest) were applied to a commercial carrot field in the Annapolis Valley, Nova Scotia. All four treatments had an early and late application, *Steinernema* and *Carpocapsae* were applied just after seeding (early application) and when carrots reached 8th true leaf (late application). The *Kraussei* and B-green systems were applied when soil temperatures exceeded 10C (early application) and when carrots reached 8th true leaf stage (late application). Soil samples were taken at regular intervals and baited with *Galleria* to determine percent infectivity and nematode persistence in soil. Preliminary results show that the Seiner system and the *Carpocapsae* system to persist in the soil for 30+ days. The *Steinernema* System is showing higher percentage infectivity and survivorship, than the *Carpocapsae* System. Preliminary results from *Kaussei* and B-Green systems are showing these two products to be less robust In vivo bioassays are underway to determine impact of entomopathogenic nematodes against all life stages of carrot weevil on planted carrot. At harvest, damage to carrots by *L. oregonensis* in experimental plots will be compared between treatments.

Udari Wanigasekara¹, Barb Sharanowski²

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Evaluating hymenopteran parasitoids for the integrated control of cutworms (Lepidoptera: Noctuidae) in the Canadian Prairies.

Parasitoids are potentially effective biological control agents for controlling cutworms, but have been underutilized as there are few studies on the biology and taxonomy of the species involved in the Canadian Prairies. We assessed the efficacy of hymenopteran parasitoids as biological control agents of economically important

cutworms in the Canadian prairies. We collected cutworm larvae from infested field crops in the Canadian prairies and reared them in the laboratory. After parasitoid wasps emerged, they were identified and we developed a taxonomic key to the hymenopteran parasitoids, with the emphasis on prominent external characteristics. *Copidosoma bakeri* and *Copidosoma cuproviridis* are likely to be the most effective parasitoids for controlling cutworms; however, DNA-based species delimitation (using COI and ITS2) was conducted to confirm the phylogenetic relationship between the species. The observed prevalence of parasitism was higher in Alberta compared to Manitoba. Prevalence is often too low to reduce cutworms below economic levels. Providing additional resources through habitat management has been shown as an effective method to increase prevalence of parasitism, and here we chose nine cover crops to test foraging preferences of *C. cuproviridis* for non-host food items. Camelina, canola and mustard attract parasitoids, but camelina was preferred when the entire plant was offered. Camelina flowers for short period and growing plants in mixtures, especially canola, camelina and mustard, would increase the overall duration of the flowering period by overlapping the complimentary flowering periods of individual species, since *C. cuproviridis* highly preferred those plants over others.

Jenny Liu¹, Boyd Mori², Owen Olfert², Jonathan Newman³, Rebecca Hallett¹
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Temperature-dependent development rates of swede midge (*Contarinia nasturtii* (Kieffer)) in southern Ontario.

The swede midge (*Contarinia nasturtii* (Kieffer)) is an exotic insect originating from Eurasia, whose feeding has caused a decline of over 60% of total canola acreage in Ontario, Canada since 2011. Management action must be undertaken to prevent impact to Canada's \$26.7 billion canola industry, beginning with the development of a reliable forecasting model for swede midge emergence in order to target the midge at its most vulnerable life stage. Current prediction of swede midge emergence is hindered by outdated information about the insect's complex life cycle, which was elicited from European populations in the late 1950s. The objectives of this project are therefore to i) determine temperature-dependent development and mortality for Ontario swede midge populations and ii) use this new information to re-develop the existing swede midge life cycle model. Temperature-dependent rates of development, mortality, viability, and incubation of various swede midge life stages were elicited using the thermal gradient plate facility at the Saskatoon Research & Development Centre, Agriculture and Agri-Food Canada. Inclusion of these current and Ontario-specific developmental rates is expected to greatly improve model accuracy and aid in developing an effective integrated pest management strategy for the swede midge.

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The influence of soil fertility on tomato tolerance to whiteflies.

Whiteflies are one of the leading causes of tomato yield loss worldwide. Phloem feeders, including whiteflies, prefer foliage with high nitrogen (N) content because organic N is a limiting factor for herbivores. Since soil N is commonly insufficient for adequate crop growth, farmers supplement soils with N-containing fertilizers. While an adequate supply of N and other nutrients is necessary for growth and fruit production, if plants with greater access to N have greater N content in their tissues, then soil N supplementation also makes plants less resistant to whiteflies. Therefore, there must be a level of fertilizer addition beyond which the losses in fruit production caused by greater attraction and feeding of pests, exceed the gains brought about by N availability. In this study, we grew four commercial tomato varieties under three levels of soil N fertilization and infested half of these plants with whiteflies after eight weeks of growth. After twenty weeks of growth, we compared the yield and resource allocation in whitefly infected and uninfested plants to find whether soil N supplementation results in greater susceptibility of tomato plants to whitefly infestation and if so, to what extent, and to find whether some varieties of tomato are more resistant or tolerant to whiteflies. From the results, we are expecting to suggest an optimum N fertilization level at which the losses in yield due to reduced N is outweighed by the benefits from the reduction of economic and environmental costs of using chemicals (fertilizers and pesticides) in tomato cultivation.

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Effect of nutrition status on the lifespan and reproductive output of the click beetle *Agriotes obscurus*.

Reproductive individuals of a species are either capital breeders, able to lay eggs regardless of nutrition, or income breeders, dependent on nutrition to lay eggs. Adult *A. obscurus* were paired and provided with an apple slice (fed) or no apple (starved) to determine the effect of nutrition on reproduction. Egg numbers and oviposition were recorded. Starved females laid fewer eggs for a shorter period than fed females, suggesting nutrition is important for *A. obscurus* reproduction, making *A. obscurus* income breeders.

John Ciancio¹, Brent Sinclair¹, Tara Garipey²

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The effect of environmental stressors on brown marmorated stink bug (*Halyomorpha halys*) overwintering physiology.

In temperate North America, insects spend a significant portion of their life overwintering, where they encounter various environmental stressors including low temperatures, desiccation, and energy drain. The brown marmorated stink bug

(*Halyomorpha halys*) is an invasive pest that damages several economically important crops - such as corn, soy, and apples - thus threatening the Canadian agricultural landscape. Here, we aim to determine the relative importance of low temperatures, desiccation, and energy drain in determining *H. halys* overwintering success, and to determine if *H. halys* stress tolerance changes seasonally. We placed groups of *H. halys* in a residential overwintering habitat, and conducted measurements of their tolerance of low temperatures, desiccation, and energy drain at three sampling points throughout the winter. *Halyomorpha halys* are chill-susceptible, and die at temperatures above their supercooling point (SCP; temperature at which internal ice formation begins). Their SCP does not change throughout winter, nor does water content or lipid and protein content; this suggests that desiccation stress and energy drain do not limit *H. halys* survival, while low temperatures may be a limiting factor. Female *H. halys* have significantly higher water content, and lipid and protein stores compared to males; however, this does not appear to enhance overwintering success because as only 39.7% of the surviving individuals were female. Overall, our study identifies potential strategies that aid in *H. halys* overwintering success, which may inform future pest management strategies, and thus control future invasions of *H. halys*.

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Overwintering energetics and microhabitat selection of the western bean cutworm.

Overwintering insects risk depleting energy stores through the warmest parts of their dormancy due to an elevation in metabolic rate. However, insects can conserve energy behaviourally, by selecting a microhabitat that buffers against high temperatures, or physiologically through metabolic plasticity. The western bean cutworm (*Striacosta albicosta*) appears to use both strategies; the depth of prepupal chambers in the soil influence the temperatures experienced while in diapause, and exposure to warmer conditions induces a decline in the thermal sensitivity of metabolism. In the lab, *S. albicosta* prepupae overwintering at warmer temperatures (16 and 20C) lowered the thermal sensitivity of metabolic rate, consumed more lipid stores, and had increased mortality relative to those at 4, 8 and 12C. We observed a similar pattern in field studies, as prepupae overwintering close to the soil surface (<15 cm depth) had a lower thermal sensitivity of metabolic rate, and less dry mass than those that occupied sites more than 15 cm below the soil. These results suggest that microhabitat depth plays an important role in determining energy use for insects that overwintering in the soil. In laboratory experiments, we also found that soil texture and temperature during burrowing influences the depth of site selection by *S. albicosta*. We hypothesize that microhabitat selection in *S. albicosta* represents a conflict between the costs of burrowing into and emerging from soil, and the increased metabolic cost of overwintering at shallower depths.

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Functional characterization of oxidative stress proteins in different mountain pine beetle populations.

Several oxidative stress protein genes are upregulated during host colonization in the mountain pine beetle, *Dendroctonus ponderosae* (Coleoptera: Curculionidae). Such proteins are likely key components of the mountain pine beetle detoxification arsenal. However the specific role of these proteins in this portion of the insect's life cycle is not well understood. We are working toward the functional characterization of mountain pine beetle superoxide dismutase, ferritin, catalase, peroxiredoxin, and glutathione peroxidase. We are analyzing, single nucleotide polymorphisms (SNPs) in the coding regions for these proteins in populations from Alberta and BC and are searching for non-conserved amino acid substitutions that may shift enzyme functional characteristics. Functional characterization of these proteins and understanding how that functionality differs between mountain pine beetle populations could improve predictions on the continued spread of the insect into the jack pine stands of the Canadian boreal forest.

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Egg parasitoids in light of UV radiation.

In terrestrial ecosystems, ultraviolet (UV) radiation is a ubiquitous abiotic factor influencing interactions within and among species by inducing important and potentially deleterious changes at molecular, physiological, and behavioral scale. The small body size of insects may render them particularly susceptible to UV exposure, but very little work has been done to investigate this issue. Because parasitoids have the capacity to detect UV wavelengths, they might adjust their host exploitation strategies in accordance with the damaging effects of UV radiation. The behaviour of these successful biological control agents in response to UV radiation is important to understand in the context of food production, where there is increasing use of UV-blocking materials in both indoor and outdoor systems. We aimed to examine how UV radiation affects *Telenomus podisi*, a parasitoid of stink bug eggs. This wasp is sensitive to high levels of UV radiation throughout its immature development, but the consequences of UV exposure on adult fitness and reproductive behaviour remain untested. We exposed newly emerged female *T. podisi* to UV radiation over their whole egg-generating period and lifespan, to record effects on longevity and egg load as proxies of adult fitness. UV exposure reduced parasitoid longevity, but had no effect on egg load. Future work will consist of behavioural experiments under laboratory and field conditions. This project represents the first step towards a more complete understanding of the impact that a pervasive but neglected environmental factor has on the performance of biological control agents.

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Long term impact of severe wildfire on macroinvertebrate assemblage structure in Alberta's Rocky Mountains.

Wildfire alters landscapes and can have significant impacts on stream ecosystems. The 2003 Lost Creek wildfire was one of the most severe to burn on Alberta's eastern slopes. The Southern Rockies Watershed Project was established to document the effects of the wildfire and post-wildfire salvage logging on hydrology, biogeochemistry and aquatic ecology. Monitoring of burned, burned & salvage-logged, and reference (unburned) watersheds revealed elevated sediment production and nutrient (phosphorous, nitrogen and carbon) export in fire-affected watersheds as well as warmer and more variable stream temperatures and increased algal productivity. Macroinvertebrate sampling was conducted eight years post-fire to explore long term impacts on macroinvertebrate assemblage structure and function. Invertebrates were identified to the finest practical taxonomic level and enumerated. Ordinations performed using non-metric multidimensional scaling (NMS) with Bray-Curtis dissimilarity matrices showed clear differences in assemblages between burned, burned & salvage-logged, and unburned watersheds. Multivariate ANOVA of the dissimilarity matrices confirmed these differences ($p=0.005$). Burned watersheds had the greatest abundance of macroinvertebrates and were characterized by higher numbers of chironomids and caddisflies. Burned & salvage logged watersheds had high numbers of riffle beetles and crane flies. Reference watersheds showed the lowest abundance of macroinvertebrates. Differences in assemblage structure between burned and reference catchments after eight years suggests the impacts of wildfire on Rocky Mountain stream ecosystems are persistent. Analysis of corresponding environmental data including physical, hydrologic, biogeochemical and ecological parameters will determine the key environmental drivers of community structure providing greater resolution of how macroinvertebrate taxa have been affected by wildfire.

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Characterization of the pheromone communication channel in bertha armyworm, *Mamestra configurata*.

The bertha armyworm (*Mamestra configurata*) is a major insect pest in Western Canada, but despite its economic importance, little is known about its genetic diversity across its geographical range. To characterize the genetics and biology of the *M. configurata* pheromone communication channel, we established colonies from three distinct geographic locations in Western Canada in addition to a pre-existing colony. Total RNA samples from head and antennae for each *M. configurata* strain were sequenced using pair-end Illumina and the resulting data subjected to de novo transcriptome assembly and bioinformatics analysis. The reference transcriptome was

used to identify and characterize 80 proteins involved in the *M. configurata* pheromone communication, including 15 olfactory receptors and 3 pheromone binding proteins. Furthermore, individual libraries from the four *M. configurata* colonies were compared to the reference transcriptome to assess genetic differences among genes involved in pheromone communication. Real-time droplet PCR confirmed the theoretical expression profiles and determined sex-biased expression of relevant genes. Detailed chemical analysis of female pheromone gland extracts performed with gas chromatography-coupled mass spectroscopy was used to investigate the chemical composition of the female pheromone gland and differences between *M. configurata* strains. This project combines the power of next generation sequencing with established physiological and behavioural bioassays to further our understanding of the lepidopteran pheromone communication channel.

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Use of kairomones by the daring jumping spider (*Phidippus audax*): a study using stink bug aggregation pheromones.

Over the last three years, high numbers of the daring jumping spider, *Phidippus audax* (Salticidae), have been observed in field traps containing an aggregation pheromone lure used to monitor various native and exotic stink bug species. The majority of *P. audax* captured are female and their appearance generally coincides with aggregations of stinkbugs in late summer. As mated females generally overwinter, we postulated that the spiders use the stinkbug aggregation pheromone as a kairomone, as this would ensure a reliable food source during fall and spring. In a series of field trials testing the importance of both colour and aggregation pheromone as attractant, it was clear that the pheromone served as a kairomone. These findings were confirmed in laboratory experiments using a Y-tube olfactometer. Very few female *P. audax* responded when only air was used in both arms, but when pheromone was present nearly all females walked upwind and significantly more selected the pheromone source over air. Female *P. audax* will actively feed on the brown marmorated stink bug but whether it will respond to the specific pheromone of this introduced pest, and thus be an important predator during the aggregation period, is currently being investigated.

17:00-18:00 Tuesday

Regular Poster Presentations

Ashraf Mashaly

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Effect of clothing on insect prevalence into rabbit carcasses in three separated habitats.

The effect of clothing on the number of insects were analysed on clothed and unclothed rabbit carcasses in three different habitats in the period from May to July 2014. In the agricultural habitat, carrion reached the dry stage within 12 days, whereas the carrion needed 6 days in the desert and urban habitats, in both clothed and unclothed carcasses. A total of 2925 insects included 2535 flies and 390 beetles were collected during the decaying process. The prevailing species of flies belonged to families Calliphoridae

and Muscidae, while families Dermestidae and Histeridae contained the prevailing species of beetles. *Lucilia sericata*, *Musca domestica*, *Dermestes maculatus*, and *Saprinus moyses* were the most abundant species occurring on both the clothed and unclothed carcasses. There were also significant differences in the insect communities evident in the clothed carcasses compared to the unclothed carcasses, and the clothed carcasses also contained the highest number of beetles and the lowest number of flies collected.

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Determining the presence of bumble bee pathogens (*Nosema bombi*, deformed wing virus) in native Saskatchewan bumble bees (*Bombus* spp.).

The introduction and subsequent establishment of non-native bumble bee species can have negative consequences that can contribute to rapid declines for some native bumble bees, and possible extinctions of others. The distribution of two sister species, *Bombus terricola* and *Bombus occidentalis*, overlaps in Saskatchewan, and both have experienced dramatic declines in parts of their ranges across North America, though not yet in Saskatchewan. Loss of native habitats rich in flowering plants, pesticide use, climate change, competition, and increased pathogen load all have likely contributed to these declines. Although some of these factors have been extensively studied, there is a shortage of research regarding bumble bee pathogens, particularly in the Canadian Prairies Ecozone. The historic and current status of pathogen prevalence in native bumble bee populations has not been studied in Saskatchewan, and there is a looming threat that pathogen spillover from commercial bumble bee introductions may occur. This project aims to determine the potential threat of two pathogens (*Nosema bombi* and *Iflavirus* [Deformed Wing Virus]) on native prairie bumble bees in relation to the presence and establishment of the introduced managed species, *Bombus impatiens*.

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Overexpression and higher sensitivity to phosphine stimulate of CYP345A subfamily contribute to phosphine resistance in *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae).

Worldwide use of phosphine fumigation to control stored grain insects has caused the development of resistance insect populations. We tested ten field populations of *Tribolium castaneum* (red flour beetle) and six P450 genes, which belong to CYP345 family. There were 4 strains with strong resistance (resistant ratios are higher than 160), 2 strains had medium resistance (resistant ratios are between 5 and 160), and 3 susceptible strains (resistant ratios are lower than 5). Cytochrome P450 was greater with greater phosphine resistance. Gene expression levels of six P450 genes were compared, and CYP345A subfamily memberships (CYP345A1 and CYP345A2) were significantly overexpressed in resistant strains, while CYP345B1, CYP345C1, CYP345D1 and CYP345D2 were not overexpressed. After phosphine exposure, the expression level of CYP345A1 and CYP345A2 were up-regulated more in resistant strains than in susceptible strains. A strong resistance strain needed 2 h to reach the

peak, while a medium resistance strain needed 12 h and a susceptible strain needed and 48 h. RNA interference via dsRNA injection was effective to turn down the expression level of CYP345A1 and CYP345A2, and resulted in an increase of sensitivity to phosphine. In conclusion, cytochrome P450 was an important detoxification enzyme and overexpression and higher sensitivity to phosphine stimulate of CYP345A subfamily genes contribute to phosphine resistance in *T. castaneum*. (Funding provided by Collaborative Innovation Center for Modern Grain Circulation and Safety)

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Suitability of hemp seed for reproduction of stored-product insects.

Hemp, or industrial hemp, is a high value alternative crop that has seen major increases in acreage in Canada since commercial production was legalized in 1998. The term industrial hemp applies to non-psychoactive varieties of *Cannabis sativa* L. There have been reports of insect infestations on stored hemp seed in Manitoba. Our objectives were to determine which stored-product insects can reproduce on hemp and the effect of dockage and seed moisture content. Twenty adult insects were placed on 15 g of hemp seed at two different moisture contents (~8% or ~15%) and two different dockage levels (~0% or ~15%) and held at 30C and 60-70% relative humidity. The number of live and dead insects were counted at 3, 5, 7 and 9 weeks. Only live adults were returned to vials. The red flour beetle, sawtoothed grain beetle, drugstore beetle and warehouse beetle populations increased over the nine weeks. The rusty grain beetle, lesser grain borer, rice weevil, flour mill beetle, confused flour beetle and cigarette beetle populations did not increase. In general, higher dockage led to higher populations. The effect of moisture content was variable.

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Hot, hot, hot – high temperature causes differential survival explained by gene transcription in a host-parasitoid system.

Insects that are parasitized by endoparasitoids commonly react with an immune response that attempts to encapsulate and melanise parasitoid eggs and larvae. However, some endoparasitic wasps such as the solitary *Tranosema rostrale* (Hymenoptera: Ichneumonidae) that lay their eggs in larvae of the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae), have evolved a symbiotic relationship with a polydnavirus (PDV), which in turn helps them suppress the hosts immune response. We observed that increasing temperature was positively related to mortality of immature *T. rostrale* and spruce budworm survival. Dissections of parasitized spruce budworm larvae reared at 30°C revealed that most parasitoid eggs or larvae had died as a result of encapsulation and melanisation by the host. We tested two hypotheses about the mechanisms involved: high temperatures (1) impede the

expression of *T. rostrale* PDV genes and (2) enhance the expression of spruce budworm immunity-related genes. A qPCR analysis of *T. rostrale* PDV (TrIV) gene expression showed that the transcription of several TrIV genes in host larvae was down-regulated at high temperature. On the other hand, the transcription of several genes related to spruce budworm's melanisation and encapsulation processes was up-regulated. Our results support the hypothesis that a temperature-dependent increase of encapsulation response is due to the combined effects of reduced expression of TrIV genes and enhanced expression of host immune genes.

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***Epitrix papa*, a damaging invasive pest of potato tubers, recently introduced into Europe, is not from Canada.**

A previously unknown species of *Epitrix* flea beetle was reported to be causing economic damage to field-planted potato tubers in Northern Portugal in 2004. It was mis-identified as *E. similaris*, a North American species. Canada was speculated to be the source of this new European invasion. Investigations conducted by European scientists confirmed the mis-identification. The introduced *Epitrix* beetle is a species new to science and was described as *E. papa*. The native origin of *E. papa* is unknown at the present time, but it is not from Canada or the United States.

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The spotted wing drosophila: did a correlation exist between monitoring and damage in raspberry in Quebec?

In Quebec, spotted wing drosophila (SWD) is a major pest of berries and insecticide sprays are recommended during harvest to protect fruits and the suggested threshold is of one fly per trap. However, the link between catches in baited traps and damage to fruits is unknown. The objective of this project is therefore to determine whether there is a correlation between trap catches and fruit damage evaluated through two methods. In 2016 and 2017, six baited traps were sampled for six weeks in five raspberries fields in Quebec located in the Montérégie, Lanaudière and Chaudières-Appalaches regions. When harvesting twice a week, 120 fruits were collected in the vicinity of each trap to count the larvae in the fruits with a salt test. In addition, 120 fruits collected on the entire plot were individually incubated to obtain the actual proportion of fruits infested with SWD. The results analyzed will be discussed in the light of the recent knowledge gained on the SWD and will provide a basis for rationalizing the use of insecticides at the beginning of the season.

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The grape rootworm, *Fidia viticida* (Coleoptera: Chrysomelidae), newly recorded from Quebec.

The occurrence of the North American native grape rootworm, *Fidia viticida* Walsh (Coleoptera: Chrysomelidae), is reported for the first time in Quebec. During the summer of 2016, adults were beaten from Virginia creeper, *Parthenocissus quinquefolia*, and riverbank grape, *Vitis riparia*, along the highway Papineau-Leblanc in Laval, QC. *Fidia viticida* is a pest of cultivated grapes in the Lake Erie area in the USA. Its current pest status in Canada is unknown.

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Brown marmorated stink bug distribution and phenology in Ontario.

The brown marmorated stink bug (BMSB) (*Halyomorpha halys* Stål) is an invasive insect pest from East Asia that was originally detected in Pennsylvania in 2001. Since then this adept hitchhiker has been detected in 43 states and established in the provinces of Ontario, Quebec and B.C. BMSBs mobility and highly polyphagous nature make it capable of causing significant economic damage to important fruit, vegetable and field crops, as well as ornamental trees and shrubs through the growing season. Survey programs for BMSB have been on-going in Ontario since 2013 with the average number of sites surveyed annually at approximately 160. As of 2016, BMSB has been detected in 19 counties, with established breeding populations in Hamilton, London, Newboro, St. Catharines, Windsor, St. Davids, Toronto and Guelph. In 2017, the number of sites surveyed using Trecé pheromone lures was reduced drastically with a focus maintained on high risk crops such as grapes, apples and peaches in the Niagara Region. In 2017, nymphs and adults have been found in pheromone traps in close proximity to at risk fruit crops elevating the level of concern amongst growers substantially. In previous years it has appeared that there may be 2 generations of BMSB in Ontario. In an effort to verify this, field collected females were assessed for reproductive status using a 5-stage ranking system based on ovary development created by Nielson et al. (2017). Results from 2017 support those from 2016 indicating there is no 2nd generation of BMSB in Ontario.

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A survey of the distribution of the pea leaf weevil (*Sitona lineatus*) in Alberta pulse growing regions using semiochemical baited traps.

Since its introduction in 1997, the pea leaf weevil (PLW), *Sitona lineatus* L. (Coleoptera: Curculionidae) has become an important agricultural pest of field peas (*Pisum sativum* L.) and faba bean (*Vicia faba* L.) in pulse growing regions of the Prairie Provinces. Economic damage is sustained by the plant as adults feed on foliage

and larvae feed throughout their development on *Rhizobium* nitrogen-fixing bacteria in the root nodules. Severe damage can result in reduced yield and reduced nitrogen fixation capacity of the pulse host plants. The pea leaf weevil is established in southern Alberta but has recently begun expanding its range eastward into Saskatchewan and northward towards the Peace River region, a pulse growing region currently free of weevil activity. The purpose of the study is to delineate the range expansion of PLW in all Albertan pulse growing regions. Pitfall traps baited with pea leaf weevil aggregation pheromone and synthetic copies of bean volatiles were positioned along the outer edge of pea and faba bean fields to monitor for PLW adults during the spring and fall adult flight periods. Plant samples were taken to determine if adult feeding damage correlates with weevil capture in semiochemical-baited traps. This survey will act as a map for pulse producers in Alberta to raise awareness of PLW range expansion in the province and throughout the pulse growing regions of the Prairie Provinces.

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Nominal action thresholds to prevent lygus seed quality damage in faba beans.

Lygus bugs (Hemiptera: Miridae) feed on soft seeds of many crops and can reduce yield or quality. In faba beans, depending on supply and demand, a grain sample must have less than 15% of seeds with damage to receive the maximum edible price premium. Samples with more than 25% of seeds with necrotic spots (lygus damage) are downgraded from the edible market to livestock feed with a substantial financial loss to growers. There are currently no thresholds to help growers make management decisions to prevent lygus damage to this crop. From 2013 to 2016, we surveyed lygus bugs in a number of faba bean fields in Alberta and completed plot tests near Lacombe, Lethbridge, Vauxhall and Saskatoon. Seed samples were also visually assessed for necrotic damage and related to lygus abundance at various crop stages. Regression analysis from a subsample of the data suggests that lygus at the early pod stage can reduce seed quality particularly in the top of the canopy. The preliminary analysis has suggested a low threshold of about 5 lygus per 10 sweeps at the early pod stage to have damage of less than 15%. Faba bean benefits from pollinators, therefore, the impact of spraying insecticide for lygus management on crop yield needs further study in commercial situations.

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Monitoring, forecasting, and risk warning systems for field crop insects on the Canadian Prairie Ecoregion.

The Prairie Pest Monitoring Network (PPMN) is a prairie-wide, coordinated insect monitoring program designed to keep the Canadian agriculture industry informed of the risks to crop production from pest species and to highlight and conserve their natural enemies. The Prairie Ecoregion contains a large expanse of approximately 29 million hectares of cropped land typically dominated by ~12 million hectares of wheat and ~6 million hectares of oilseed rape (canola) seeded annually. Given the periodic or cyclical nature of insect outbreaks, production risks associated with insect pests can be minimized through a coordinated monitoring program that provides decision-support to the agriculture industry in a timely manner. The PPMN is supported by researchers at the federal, provincial and university levels and involves key agricultural industry partners. The PPMNs participants all strive to develop sustainable pest management strategies capable of maintaining the productivity and quality of agricultural field crops grown on the Canadian prairies. An additional, yet essential, component of the PPMNs activities includes the monitoring of beneficial organisms which contributes to their conservation but also to the development of reduced-risk strategies for the management of pest species. The PPMN has a 20-year history of prairie-wide collaboration, a website (<http://www.westernforum.org/IPMNMain.html>), and a Blog (<http://prairiepestmonitoring.blogspot.ca/>) with ongoing efforts to continue to address climate change, new agronomic practices, new crops and the diversity of pest and beneficial arthropods that utilize field crop production systems in Canada.

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Proposal for a ‘standard’ field study for the evaluation of the effects of parasiticides on dung and soil organisms.

European registration of new veterinary medical products (VMPs) necessitates that they be assessed for non-target effects. Pending the outcome of laboratory bioassays, subsequent field or “higher tier” tests may be required. However, no guidelines for such studies have been approved by the Organisation for Economic Co-operation and Development (OECD). To address this need, we developed and validated a field test method in four countries under varying conditions of climate, soil, and endemic coprophilous fauna; i.e., Lethbridge (Canada), Montpellier (France), Zurich (Switzerland), Wageningen (the Netherlands). Using the VMP ivermectin as the test substance, our method produced comparable results across sites when assessing the effect of ivermectin on: (1) insects breeding in dung of ivermectin- treated cattle, (2) coprophilous organisms in the soil beneath the dung, and (3) rates of dung degradation. Results of this international study were published in a series of articles in *Environmental Toxicology and Chemistry* (2016. Vol. 35(8):1914-1977). This poster summarizes the “lessons learned” from a methodological point of view. In brief, our

field method meets OECD requirements for a higher tier field test. It provides for detailed recommendations regarding the selection and description of the study site, experimental design (e.g., replicate number), application of the test substance (including verification of residue concentration), key structural and functional endpoints, and how to measure these endpoints. Our field test method recently has been published for public consultation by the European Medicine Agency as part of a longer term process for acceptance as an OECD approved guidance document.

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An efficient trap for monitoring onion maggot flies.

The onion maggot (*Delia antiqua* Meigen) feeds at the base of onion plants, killing or damaging the onions. The populations of adult onion flies are monitored using yellow sticky traps situated near field edges. The first integrated pest management program for onions in the Holland Marsh region of Ontario began in 1980 and involved monitoring onion maggot flies. Each trap consisted of three wooden stakes placed 0.3 m apart, with a yellow-painted milk carton, covered with Tangle-Trap, stapled to each stake. Stakes were pounded in to the soil, Tangle-Trap was applied to the cartons in the field, and the carton was stapled to the stake. A more efficient method was developed by the authors in 1985. Milk cartons were printed a solid yellow colour by the supplier. Tangle-Trap was applied indoors and cartons were carried to the field in packages of 12, in a folder made of an opened carton. The most important advance was the introduction of 5 mm diameter aluminum rods to replace wooden stakes. These were cut to 1.3 m and the top 20 cm was bent with a vice grip to hold the milk cartons. Holes near the top of each flattened carton allowed the carton to be threaded on to the stake. The rods could be pushed in to the ground to place the bottom of the carton at the top of the onions, and then pulled up to keep the traps at canopy height. These changes improved the efficiency of monitoring onion flies.

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Changes in behaviour of carrot weevil larvae in Ontario.

Carrot weevil (CW), *Listronotus oregonensis* (LeConte), is a major pest of carrots in the Holland Marsh region of Ontario. Eggs are deposited in leaf bases and roots of young carrots and larvae tunnel into the roots, resulting in unmarketable carrots. A change in the type of damage to carrot roots was first noticed in 2009. Young carrot plants were found dead, with larvae and/or tunneling damage through the vascular tissue, suggesting CW attack was resulting in mortality. In 2016 and 2017, trials were conducted at the Muck Crops Research Station, in the Holland Marsh, to assess the extent of carrot death caused by weevil damage. Carrots were seeded at ten-day intervals starting May 1, with five to six planting dates. In 2016, stand counts were performed in late July and in 2017 stand counts began at the 2nd true leaf stage and continued weekly until late July. CW oviposition was also tracked throughout the season, using carrot root pieces as bait. The earliest seeded carrots had 8.4 ± 1.4 and 5.4 ± 1.0 dead carrots per m², while the latest seeding had 2.2 ± 1.4 and 0 dead carrots

per m² by late June in 2016 and 2017, respectively. This documents the loss of carrot plants as the result of CW attack and suggests that earlier applications of control measures may be needed. The change in CW behaviour requires more research to determine the extent of crop loss and most effective spray timings for insecticides or biological controls.

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Phylogenetic analysis and diversity of *Bemisia tabaci* species complex from Pakistan.

The whitefly species, *Bemisia tabaci* (Gennadius), has always been regarded as a pest to a large range of worldwide crops. They are capable of transmitting plant viruses of different groups. Genetic diversity analysis of whitefly based upon phylogenetic analysis of DNA sequence of mitochondrial gene Cytochrom Oxidase I (mtCOI) across Pakistan was conducted. All sequences of mtCOI genes of whitefly samples from different geographical areas in Pakistan surveyed in this study were grouped with genetic group *B. tabaci* (Asia II), which includes biotypes H, K and P. Sequencing results showed that clones obtained were less diverse as they had 98.3% to 99.6% identity among themselves and 98.7% to 100% identity with the reported sequences available in databases. This study emphasizes more focus on molecular analysis of whiteflies and it provides relatively widely distributed data regarding the molecular characterization of whitefly from Pakistan.

Zachariah Telfer¹, Mary Ruth McDonald², Cynthia Scott-Dupree¹

¹School of Environmental Sciences, University of Guelph, Guelph, ON; ²Department of Plant Agriculture, University of Guelph, Guelph, ON; ztelfer@uoguelph.ca

Evidence of a second generation of carrot weevil in Ontario.

Carrot weevil (CW), *Listronotus oregonensis* (LeConte), is a major pest of carrots in the Holland Marsh region of Ontario. Carrots are rendered unmarketable due to CW larvae tunnelling inside the root. Historically, CW has only had one generation in Canada. Recently, CW damage has been increasing and it is believed the CW is developing a second generation. In 2015 and 2016, nine trials at the Muck Crops Research Station in the Holland Marsh region of Ontario were conducted to examine CW control options. All trials were sampled in the middle of the growing season and at harvest to assess the potential change in CW damage after the first generation was completed. In seven of nine trials, CW damage significantly increased between these sampling dates. By harvest, CW damage increased by $109.2 \pm 8.1\%$. In addition to the increase in damage, 1st to 3rd instar larvae were found in carrot plants as late as October. These observations suggest a second CW generation is occurring in the Holland Marsh region. There are no recommendations for controlling a second generation. Further complicating CW management is that monitoring relies on carrot baits that become ineffective as the developing crop matures, meaning this second generation is unable to be measured accurately. Additionally, carrots developed a closed canopy that can limit the coverage of insecticide applications. Future research is needed to establish CW monitoring methods that avoid relying on carrot baits and evaluating the efficacy of insecticide applications for second generation CW.

Haley Catton¹, Héctor Cárcamo¹, Alejandro Costamagna²

¹Agriculture and Agri-Food Canada, Lethbridge, AB; ²Department of Entomology, University of Manitoba, Winnipeg, MB; haley.catton@canada.ca

Seeing both sides of the coin: putting dollars values on pest and beneficial arthropods.

Agricultural fields contain a mix of arthropod species, including some that cause crop losses (pests) and others that provide value (beneficials). Insecticide use harms both groups of arthropods, sometimes leading to unintended negative consequences. Optimal use of pesticides can only come when producers have information on both the economic losses caused by their target pest, and the economic value provided by the beneficials. Cereal leaf beetle (*Oulema melanopus*, Coleoptera: Chrysomelidae) is an invasive crop pest from Eurasia, new in Alberta since 2005. Larval feeding causes yield loss, and economic thresholds for insecticide application in wheat (*Triticum aestivum*) are estimated in the USA to be 0.4-1.0 larvae per flag leaf. Since 2009, the larval parasitoid *Tetrastichus julis* (Hymenoptera: Eulophidae) has been widely relocated across the Canadian prairies, and is expected to prevent cereal leaf beetle populations from reaching damaging levels. Generalist predators (e.g., spiders, lady beetles, carabids, nabid bugs) may also consume cereal leaf beetle larvae. We present preliminary results from an outdoor cage experiment aiming to assign value to cereal leaf beetle, *T. julis*, and generalist predators in a Canadian prairie agroecosystem. The study was conducted on a wheat field near Lethbridge, Alberta, as a randomized complete block. We manipulated numbers of cereal leaf beetles, *T. julis*, and generalist predators to assess effects on insect communities at harvest, plant biomass, and grain yield. The results will be used to develop economic thresholds, quantify the value of beneficials, and lead to more informed decision-making regarding pesticide use in prairie wheat fields.

Jessica Leung, **Paul Abram**

Agassiz Research and Development Centre, Agriculture and Agri-Food Canada, Agassiz, BC; paul.abram@canada.ca

Associative learning induced persistence of parasitoids in mulch.

Retaining natural enemies released into agricultural systems is a key challenge for augmentative and inundative biological control programs. Learning could help to retain natural enemies if they could be trained prior to release to associate substrates where hosts are present in agricultural fields with rewards (e.g., feeding, mating, oviposition). Here, we investigated whether *Pachycrepoideus vindemniae*, a pupal parasitoid of a serious economic berry crop pest, *Drosophila suzukii*, could learn to associate agricultural mulch (where *D. suzukii* pupates in berry fields) with host pupae. We conducted laboratory experiments where mated *P. vindemniae* females were trained with treatments of (1) sawdust and no *D. suzukii* host pupae, (2) no sawdust and no *D. suzukii* host pupae, (3) sawdust and *D. suzukii* host pupae, or (4) no sawdust and *D. suzukii* host pupae. Parasitoid females were then assayed to measure their residence time in a patch of sawdust. Residence times in sawdust and the number of *P. vindemniae* and *D. suzukii* emerging from pupae in each training treatment were recorded. As expected, the residence times of *P. vindemniae* assayed on sawdust increased with the number of *D. suzukii* pupae parasitized during training (estimated with offspring emergence), but only if they had previously parasitized the pupae in the

presence of sawdust. Our results confirm that *P. vindemniae* is capable of associative learning during oviposition and raises the possibility of retaining parasitoids in targeted sites using cues already present in agricultural systems.

Ana Dal Molin¹, Barbara Sharanowski²

¹Universidade Federal do Espirito Santo, Vitoria, Brazil; ²Department of Biology, University of Central Florida, Orlando, Florida, USA; chalcid1@gmail.com

Interactive identification tools: a pathway in user-centered design.

Digital interactive keys have been seen for a long time as promising tools to make the bridge in organismal identification between taxonomists and non-taxonomists. New technologies have greatly expanded the potential reach of such tools, so that current limitations that have affected their availability to the general public generally involve the expansion of mobile networks and the speed in which taxonomists can improve them based on user feedback. This work focuses on the latter, an approach referred to as user-centered design (UCD), with two main questions: what kinds of characters do users mostly rely on when using an interactive key, and how can they be optimized to match taxonomic diagnoses more accurately. Interactive, multiple-entry keys were developed using Lucid 3.1, exported using the open Structured Descriptive Data (SDD 1.1) standard and made public through a customized application interface. The target taxa were included based on regional crop pest lists. The initial criteria for constructing identification characters were ease of observation in field and ease of description for lay users. A second set was based on taxonomic descriptions of pest species and dichotomous keys. The expectation is that with improved bridges between these two sets, identification tools can be more comprehensive and not focus only on species that produce economic damage. Thus, this poster presentation serves a dual purpose: to gather input on character use from entomologists through direct observation of their interaction with the keys and to obtain feedback on the performance of keys that are already available. Disclaimer: we are collecting data on which characters are selected by the users during their use of the interactive keys to improve further development of interactive taxonomic tools.

C-Jae Breiter, Laura Burns, Stephen Petersen

Assiniboine Park Zoo, Winnipeg, MB; CBreiter@assiniboinepark.ca

Grassland butterfly conservation and headstarting program.

Grasslands are central to the natural and cultural heritage of Manitoba but have undergone significant changes since European settlement. Habitat changes linked to human disturbance has resulted in <1% of native tall grass prairie remaining, and consequently many prairie specialist species have dramatically declined. One of these species is the Poweshiek skipperling (*Oarisma poweshiek*). This butterfly is currently listed as Endangered in Canada and in the U.S. Historically, *O. poweshiek* was found throughout the tall grass prairie of central Canada and Midwestern U.S.; though now are limited to a few, fragmented locations in Manitoba, Michigan, and Wisconsin. Initial recovery efforts focused on habitat management; however, due to extremely low population numbers across their range and low dispersal ability, other options are being explored. In 2016, a headstarting program was initiated at the Assiniboine Park Zoo with the aim to propagate at risk grassland butterflies, develop successful ex situ husbandry techniques, and conduct research into species biology and threats. The

program began with the capture and egg collection of 10 adults of a surrogate species, the Garita skipperling (*Oarisma garita*), to test alternative husbandry techniques that could be applied to *O. poweshiek*. *O. garita* was selected as it is closely related to *O. poweshiek*, yet is considered widespread and abundant. In 2017, two female *O. poweshiek* were captured and eggs collected before being released. This is a summary of the 2016 husbandry activities, successes and failures, and future plans for the Poweshiek skipperling headstart program at Assiniboine Park Zoo.

Dezene Huber¹, Steven Burian², Douglas Currie³, Daniel Erasmus¹, Donna Giberson⁴, Claire Shrimpton¹

¹Ecosystem Science and Management, University of Northern British Columbia, Prince George, BC; ²Southern Connecticut State University, New Haven, Connecticut, USA; ³Royal Ontario Museum, Toronto, ON; ⁴University of Prince Edward Island, Charlottetown, PE; huber@unbc.ca

First records of *Baetis vernus* (Ephemeroptera: Baetidae) in North America.

The *Baetis vernus* group that includes *B. brunneicolor*, *B. bundyae*, *B. hudsonicus*, *B. liebenauae*, *B. macani*, *B. subalpinus*, *B. tracheatus*, and *B. vernus* is both diverse and rather taxonomically tangled. Some members of the group, *B. brunneicolor*, *B. bundyae*, and *B. hudsonicus*, have been found previously in North America. The rest of the group members are only known to be of Palearctic distribution. We report the collection of several specimens from the Northwest Territories and British Columbia that we have identified as *B. vernus* using morphological keys and DNA barcoding. Support for a genetically cohesive Holarctic clade for *B. vernus* is interesting, considering their likely low dispersal capabilities. This substantial expansion of the known range of *B. vernus* adds new phylogeographic and ecological complexity, but may also help to provide further clues to the evolutionary history of this group. Author names are listed alphabetically. DH is first author simply due to his role as presenting author.

Kateryn Rochon¹, Shaun Dergousoff², Neil Chilton³

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Geographic variation in abundance and genetics of the anaplasmosis vectors *Dermacentor andersoni* and *Dermacentor variabilis*.

The Rocky Mountain wood tick (*Dermacentor andersoni*) and the American dog tick (*Dermacentor variabilis*) affect the health of livestock through the transmission of pathogens, such as *Anaplasma marginale*, which causes bovine anaplasmosis. We drag sampled 2 km² for host-seeking ticks at 201 unique sites throughout British Columbia, Alberta, Saskatchewan and Manitoba in 2014-2016. We collected *D. andersoni* from 33 sites (BC, AB & SK), *D. variabilis* from 76 sites (SK & MB), and both species were found together at nine sites in Saskatchewan. The distributional overlap is due to the westward migration of the dog tick by approximately 300 km over the last decades. *Dermacentor variabilis* was also collected at least 350 km north of the known geographic limits in Saskatchewan and Manitoba. In contrast, the range of *D. andersoni* appears to be consistent with previous reports, but has expanded northward

by approximately 150 km in central Saskatchewan. Tick abundance varied among different locations within the same year and among years at the same location. The prevalence of both tick species was influenced by temperature and precipitation, but conditions for peak prevalence differed between species. We compared the DNA sequences of 16S ribosomal DNA and cytochrome oxidase 1 for *D. andersoni* and *D. variabilis* from several populations in western Canada. The 16S rDNA gene showed much less genetic variation than did the CO1 gene. However, there were geographic patterns for both markers, indicating that populations of both species of ticks are becoming genetically distinct from each other.

Paul Manning, G. Chris Cutler

Department of Plant, Food, and Environmental Sciences, Dalhousie University, Halifax, NS; paul.manning@dal.ca

Influence of competition on biodiversity-ecosystem functioning relationships in a dung beetle community.

Nearly two decades of experiments, and subsequent synthesis have demonstrated that ecosystems with higher levels of biodiversity support higher levels of ecosystem functioning. For insects that use ephemeral and patchy resources (e.g., dung beetles), competitive interactions within and amongst species often drive greater resource use (e.g., dung removal), in turn supporting higher levels of ecosystem functioning (e.g., decomposition). When complementarity amongst species is low (i.e., species are competing for the same resources), and communities are not resource limited, increasing density might have stronger benefits for ecosystem functioning than increasing biodiversity. We explored this phenomenon with a mesocosm experiment, using three widespread species of dung beetles (Coleoptera: Scarabaeidae), at a typical field density and an elevated density (1.5X field density). Our approach allowed us to determine how increasing competition influenced biodiversity-ecosystem functioning relationships. Using additive models, we also determined whether estimates of functioning taken from single species assemblages, could reliably be used to predict functioning in multi-species assemblages.

Shelby Gibson, Amanda Liczner, Sheila Colla

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Common versus rare bumble bee (*Bombus* spp.) foraging behaviour in southern and western Ontario.

This study aimed to determine if there is any difference in floral resources preferences in common and rare bumble bees. Historical data from the past fifteen years was used to determine areas of southern and western Ontario with records of rare bumble bees. Surveys were conducted at each of the nineteen sites three times throughout the bumble bee active season to represent early, mid, and later summer flowering of floral resources. Two transects at each site, divided into five quadrats, and were surveyed for bumble bees. Species of bumble bees and plants were recorded, as well as whether the each bee was collecting nectar or pollen. This information will be useful for future studies wishing to use various conservation methods to preserve bumble bee populations, such as captive breeding and release programs.

Alex Torson, Drake Martin, Sarah Crispell, Meng Lei Zhang, Lamees Mohammad, Adam Smith, Brent Sinclair, Amanda Roe
Natural Resources Canada; atorson@uwo.ca

You are what your mother eats: maternal rearing condition impacts future larval growth trajectory in Asian long-horned beetle.

Laboratory insect colonies are essential to many research programs, but rearing conditions are an approximation of the insect's natural environment. The impact of these artificial rearing conditions on insect physiology is often under appreciated. Asian long-horned beetles (ALB) (Cerambycidae: *Anoplophora glabripennis* (Motschulsky)) are a high risk invasive species in North America and a laboratory colony is maintained at the Insect Production and Quarantine Laboratory at the Great Lakes Forestry Centre in Sault Ste. Marie, ON. We sought to streamline rearing protocols of ALB by providing artificial egg laying substrate instead of fresh log bolts. Surprisingly, larvae from these two protocols differed significantly in weight (log >artificial), despite unlimited larval food availability following hatching. These results suggest an unrecognized impact of maternal rearing conditions on long term larval growth in ALB. This is an important consideration for insect rearing facilities and the long term health of insect laboratory colonies.

Jean-Philippe Parent, Paul Abram

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What's the new buzz for agriculture? Potential use of disruptive sound as an insect pest control method.

Researchers are always striving to find new control methods for agricultural pests. With multiple commercially available insecticides being potentially phased out, the need for alternatives is even more urgent. Alternative methods such as mating disruption with pheromones, push-pull using semiochemicals, and various biological control-based methods have been and continue to be developed. Another alternative, the use of sounds and vibrations as a pest control method, has yet to receive adequate attention. As far as we know, a control method relying on sounds and vibrations as a general disruptor of agricultural pest behaviours has yet to be properly tested. Loud noises could potentially disrupt restorative resting periods and subsequent performance of pests, be used as a repellent, or even be used as mating disruption in some cases. A general overview of previous work on the impact of sound and vibrations on insects will be presented and how these could potentially be used as control method for pests will be presented. Preliminary experimental data will be presented and analyzed. Advantages and challenges of this method will also be discussed.

Julien Saguez¹, Louise O'Donoghue¹, Sébastien Boquel², Annie-Ève Gagnon³, Philippe Giordanengo⁴, Charles Vincent³

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³Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu

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Studying the feeding behavior of the soybean aphid with electropenetrography.

Electropenetrography (EPG) is a method largely used to study the feeding behaviour of piercing-sucking insects, notably aphids and cicadellids. It allows to record specific electrical signals (waveforms) when an insect inserts its mouthparts in the plant tissues. Depending on the type of signal, their frequency and their duration, it is possible to quickly characterize the plant resistance profile to a given pest. Our goal was to optimize the process of varietal selection in order to develop new soybean cultivars resistant to soybean aphid (SBA), *Aphis glycines* Matsumura (Hemiptera: Aphididae). We used 10 new soybean lines developed in a breeding program and that expressed one or more genes known for SBA resistance (Rag1b, Rag1C, Rag3, Rag4). For each line, EPG was performed on eight SBA feeding on eight plants for 8 h. Antixenosis and antibiosis resistance was determined based on alterations or not in feeding parameters, such as time spent not feeding, frequency of food intake, time spent feeding on the xylem and duration of phloem ingestion. The preliminary results of this study and the applicability of its promising methodology to a soybean varietal selection program will be discussed.

Jarrett Blair, **Charles-Etienne Ferland**

University of Guelph, Guelph, ON; jblair@uoguelph.ca

Insect ID: Using convolutional neural networks (CNNs) to photo identify insects on any mobile device.

Advances in technology have made it possible to use convolutional neural networks (CNNs) to identify objects in photos almost instantly. Fields such as ornithology and botany have already taken advantage of this technology by developing mobile applications that allow any user to instantly identify birds and plants. These apps have been greatly beneficial for citizen science initiatives in their respective fields. However, there is a severe lack photo identification mobile applications for entomological purposes. Entomology has been a leader in biological citizen science for centuries with the donation of countless amateur insect collections over the years. To ensure that entomology does not lose its stance as a citizen science leader, there should be significant effort to adapt these new identification tools for entomological purposes. Insect ID is a University of Guelph student-operated project aiming to develop a mobile app for photo identifying insects using CNNs. We present our methods for building the app and explore future applications of CNNs for entomological purposes.

**The Entomological Society of Manitoba
73rd Annual Business Meeting**

**21 November 2017
Tier Building, University of Manitoba**

Attendance

President	John Gavloski
President-elect	Mahmood Iranpour
Past President/Scientific Program	Paul Fields
Secretary	Sarah Semmler
Proceedings Editor	Terry Galloway
Member-at-large Colwell	Megan
Common Names, Member-at-large	Jason Gibbs
Social Committee	Gina Karam
Regional Director, Web Page, Archives	Rob Currie

Kateryn Rochon (2017-18 Regional Director)
 Erica Smith (2017-18 President-Elect)
 Robert Wrigley
 Todd Lawton
 David Wade
 Neil Holliday
 Bob Lamb
 Jeff Marcus
 Katarina Humniski

Regrets

Treasurer	Kathy Cano
Endowment Fund	Richard Westwood
Scholarships and Awards	Désirée Vanderwel
Scrutineer	Colin Demianyk
Newsletter Jordan Bannerman, Marjorie Smith	
Fundraising	Position Vacant
Youth Encouragement	Arash Kheirodin

1 Acceptance of Agenda

Motion: to accept the Agenda (**Appendix A**) - Rochon/Lamb..... Carried

2 Acceptance of the Minutes of the Last Annual Business Meeting (29 October 2016)

Motion: to accept previous Minutes of the 72nd Business Meeting –
Galloway/Lamb Carried

3 Business Arising from the Minutes

No new business.

4 **Reports – Executive**

Motion: to receive the reports - Lamb/Rochon Carried

Appendix B – President

Gavloski –The membership committee has been dissolved and the duties moved to the office of the secretary.

- The proposed changes to the Entomological Society of Manitoba by-laws were accepted by the members. The 2 main changes are the creation of a scholarship fund, and providing for electronic ballots to be used for elections. The revised by-laws will be posted on the website in the next month or two.

Appendix C – Treasurer

Cano absent. Report presented by Gavloski. Note that the Treasurer’s report also includes the Finance Report.

Appendix D – Regional Director to the ESC

Presented by Currie. Reminder to check on your membership status with the ESC. ESC members can now opt to have automatic renewal set up on their credit cards.

Fields – Can the regional societies send a reminder to renew to their membership?

Holliday – Yes, if the target individual is currently a regional society member, or has been one in the last two years.

Appendix E – Editor of the Proceedings

Presented by Galloway – The Proceedings was a little shorter this time, but there are four publications up for submission to the next edition.

Fields – Is there a deadline for submission?

Galloway – Sooner than later. The length of time required is based on the review process.

Appendix F – Endowment Fund Board

Westwood absent. Report presented by Gavloski.

5 **Reports – Committees**

Appendix C - Finance

Cano absent. Report presented by Gavloski.

Fields – The ESC-ESM JAM made a profit of a few thousand dollars. There should be money coming back to the ESM.

Gavloski – The JAM expenses are still being completed by Cano.

Holliday - \$4000 was put into an account used to finance ESC, should be similar between years.

Rochon – (read Under Expenditures section of report), report explains the \$4000. In the minutes from 2016, there was a question about the Youth Encouragement funding coming in from ESC.

Holliday - \$400 from the ESC goes to Youth Encouragement.

Marcus – Would have happened in October.

Gavloski – (agrees), Kheirodin received a cheque from ESC, which has been submitted to the treasurer for depositing in the ESM bank account.

Appendix G – Newsletter

Bannerman and Smith absent. Report presented by Gavloski. Three issues of the ESM newsletter were produced in 2017. Members were encouraged to submit articles.

Appendix H – Social

Presented by Karam. Upcoming events should be submitted to the Social Committee.

Semmler – Does ESM use social media to promote events?

Colwell – There's a U of M entomology student Facebook group. Unsure about twitter.

No Report - Youth Encouragement/Public Education

Did not receive report from Kheirodin.

Colwell – Heard that he is working on shifting role to Crystal Almdal, and that they are working on a report.

Karam – Had a CANU event – education for inner city kids, about 35 -40 attended. Had insect stations and a veterinary station. Also had a WISE event with a youth group that included a scavenger hunt and presentation about familiar insects.

Appendix I – Archives

Presented by Currie. Note that this is combined with the Web Page report. Should be combined in agenda at next ABM.

Fields – Is there a digital backup of the web page?

Currie – May be a backup on the university server, but is backed up on personal computer.

Fields – There may be backup services available.

Gibbs – The Biodiversity Library may backup the journals?

Holliday – Question of whether the provincial or university archives should hold originals of Criddle papers, journals. More than just digital documents to archive.

Appendix J – Common Names

Presented by Gibbs. Chair of this committee has been transferred from Terry Galloway to Jason Gibbs. One common name was proposed to the Entomological Society of Canada: spotted-wing drosophila for *Drosophila suzukii*. Still some outstanding names to look into. Send suggestions.

Appendix K – Scholarships and Awards

Vanderwel absent. Presented by Gavloski. Shared comments from Chair that the candidates were very good and closely matched, and that deciding on a winner was difficult.

Fundraising – No report, Chair vacant

Gavloski – was in touch with a potential Chair who was busy at the time, but will follow up with them soon.

Appendix L – Scientific Program

Presented by Fields. An ESC-ESM Joint Annual Meeting was held October 22 to 25th at the Fairmont Winnipeg. There was about \$2000 in profit from this meeting, and registration fees were kept low.

Appendix M – Membership

Presented by Semmler. The duties of the ESM membership committee have been transferred to the secretary, as the membership committee has been dissolved. This will result in one person maintaining the membership list, rather than the list being shared by multiple committees. We currently have 86 members.

Web page – See Appendix I

Currie – Web page updates go up pretty fast. Just getting new login info for the page. Send ideas for posts.

6 **Appendix N - Election Results**

Demianyk absent. Presented by Semmler.

President Elect Erica Smith

Member-at-large Jason Gibbs

Regional Director to the ESC Kateryn Rochon

Approval of changes to the ESM bylaws..... Yes

Motion: to destroy the ballots – Holliday/Currie Carried

7 New Business

There was no new business to discuss.

8 Moment of Silence for Deceased Members This Year

No deceased members were brought forward.

9 Transfer of Office – Iranpour had to leave early, symbolic transfer of office by Gavloski

10 Other Business

No other business to discuss.

11 Adjournment – 1:22 p.m.

Motion: to adjourn the meeting - Lamb/Currie..... Carried

APPENDIX A

The Entomological Society of Manitoba, Inc. Agenda of the Entomological Society of Manitoba 73rd Annual Business Meeting

21 November 2017

1. Acceptance of Agenda
2. Acceptance of the Minutes of the Last Annual Meeting (29 October 2016)
3. Business Arising from the Minutes
4. Reports – Executive
 - President** – John Gavloski
 - Treasurer** – Kathy Cano
 - Regional Director to the ESC** – Rob Currie
 - Editor of the Proceedings** – Terry Galloway
 - Endowment Fund Board** – Richard Westwood
5. Reports – Committees
 - Finance** – Kathy Cano
 - Publicity/Newsletter** – Marjorie Smith/Jordan Bannerman
 - Social** – Gina Karam
 - Youth Encouragement/Public Education** – Arash Kheirodin
 - Archives** – Rob Currie
 - Common Names** – Jason Gibbs
 - Scholarship and Awards** – Désirée Vanderwel
 - Fund-Raising** – Vacant
 - Scientific Program** – Paul Fields
 - Membership** – Sarah Semmler
 - Web Page** – Rob Currie
6. Election Results – Scrutineer, Colin Demianyk
7. New Business
8. Moment of Silence for Deceased Members This Year
9. Transfer of Office
10. Other Business
11. Adjournment

APPENDIX B

Entomological Society of Manitoba President's Report – Annual Business Meeting November 21, 2017

There were four meetings of the Executive committee of the Entomological Society of Manitoba in 2017:

First Executive Meeting – February 16, 2017 – Entomology Library, University of Manitoba.

- Whether the Entomological Society of Manitoba (ESM) needs **Directors and Officers Insurance** was discussed. The consensus was that ESM does not need Directors and Operators Insurance at this time.
- A suggestion had been made that the secretary could handle memberships, rather than having a separate **membership committee**. This would eliminate multiple membership lists. A motion was passed to dissolve the membership committee and move duties to the office of the secretary.

Second Executive Meeting – May 24, 2017 – Entomology Library, University of Manitoba.

- Several committees received new chairpersons or had vacancies filled since the last executive meeting. **Changes to Committee Chairs** include:
 - The membership committee was dissolved, and duties moved to the secretary.
 - The Common Names Committee, previously chaired by Terry Galloway, is now chaired by Jason Gibbs.
 - The Scholarship and Awards Committee, previously chaired by Richard Westwood, is now chaired by Désirée Vanderwel.
 - The Endowment Fund is now chaired by Richard Westwood
 - The Social Committee is now chaired by Gina Karam
- A nomination of Todd Lawton for the **Norman Criddle Award** was reviewed, and it was decided to submit this to the Entomological Society of Canada (ESC) awards committee.
- Regional entomological societies, including the ESM, reviewed **proposed changes to funding future ESC meetings**. Major changes related to cash flow and increased cash advances to regional societies. The ESM supported the proposed changes.

Third Executive Meeting – July 28, 2017 – Conference Call

- This meeting was called to outline proposed **changes to the ESM by-laws**.
- The two main changes are the creation of a scholarship fund, and provision for electronic ballots to be used for elections.

- To amend the by-laws, proposals to amend or repeal must be shown to the Active Members for consideration at least once, and at least two months shall elapse before a vote can be called.

The proposed changes to the ESM by-laws were sent to all active members of the ESM and when election ballots were sent out, members were also asked to vote on “Do you support the proposed amendments to the Entomological Society of Manitoba By-Laws”. The proposed changes were accepted by the members.

Fourth Executive Meeting – September 20, 2017 – Entomology Library, University of Manitoba.

- The main objectives at this meeting were to plan a November business meeting for the ESM, as having this meeting separated from the ESC-ESM Joint Annual Meetings would be preferred, and to prepare the ESM elections.

I thank the committee chairs and all those who volunteer their time to the Entomological Society of Manitoba. I also thank the society for the opportunity to be President and serve the society in this way.

John Gavloski

November 21, 2017

APPENDIX C
ENTOMOLOGICAL SOCIETY OF MANITOBA INC.
Treasurer's Report



THE ENTOMOLOGICAL SOCIETY OF MANITOBA INC.

Financial Statements Year Ended
August 31, 2017

Note: These Financial Statements have not been audited. The Accounts, Bank Statements and Receipts were provided by the Treasurer and will be reviewed by the incoming President in December 2017.

Treasurer: Kathy Cano
Date: 21 November 2017

ENTOMOLOGICAL SOCIETY OF MANITOBA INC.
Statement of Financial Position
August 31, 2017

	2017	2016
ASSETS		
CURRENT		
Cash	\$4,468	10,229
Money market fund	0	3,761
TERM DEPOSITS	\$46,000	\$45,000
TOTAL	\$50,468	\$58,990
LIABILITIES		
CURRENT	\$ NIL	\$ NIL
NET ASSETS		
Unrestricted net assets	\$4,468	\$13,990
Internally restricted	\$46,000	\$45,000
	\$50,468	\$54,900

NOTE: The Money Market (T-Bill) account was closed and \$3,762.43 was deposited into the ESM daily interest chequing account. \$1,000.00 of this was added to the maturing GIC on Dec 2, 2016 to top up GIC – 0019 to \$10,000.

ENTOMOLOGICAL SOCIETY OF MANITOBA INC.

Statement of Financial Position August 31, 2017

	2017	2016
REVENUES		
Annual meeting	\$ 825	1130
Donations	1450	1550
ESC	0	4000
Interest income	908	909
Membership fees	1467	1250
Miscellaneous	2762	81
Proceedings	0	75
Youth encouragement & public education	<u>0</u>	<u>425</u>
	<u>7412</u>	8995
EXPENDITURES		
Awards and scholarships	2450	1600
Donations	0	0
General	38	192
Meetings	0	930
ESC/ESM	6179	1500
Newsletter	0	0
Proceedings	0	651
Social committee	220	190
Youth encouragement & public education	<u>0</u>	<u>107</u>
EXCESS (DEFICIENCY) OF REVENUES	<u>8762</u>	4519
OVER EXPENDITURES	<u>\$(1350)</u>	4476

NOTE:

Miscellaneous expenses under REVENUE reflect the balance of the T-Bill account that was withdrawn in November 2016.

UNDEREXPENDITURES:

1. Awards and scholarships:

It was decided to present two \$1,000 graduate student scholarships at the ESM Annual meeting in 2016

2. ESC/ESM:

\$ 4,000 that was originally deposited into the ESM account from ESC in the last fiscal year as a start-up loan was transferred into a special account for the ESC 2017 expenses. The additional expenses reflect one speaker's travel expenses from the USA and expenses for the mixer and meeting refreshments.

In the last fiscal year, ESM provided a deposit of \$1,500 to the Fairmont hotel for the ESC meeting in 2017; accounts have not yet been settled for the ESC meeting in October 2017.

ENTOMOLOGICAL SOCIETY OF MANITOBA INC.
Statement of Financial Position
August 31, 2017

TERM DEPOSITS

Certificate Number	Interest Rate (%)	Purchase Date	Maturity Date	Par Value (\$)	Interest (\$)
900055611-0015	2.05	9 Nov 2012	9 Nov 2017	9,000	184.50
90005561100016	2.10	12 Dec 2012	12 Dec 2019	9,000	189.00
900055611-0017	2.00	17 Nov 2014	17 Nov 2019	9,000	180.00
900055611-18	2.00	19 Nov 2015	19 Nov 2020	9,000	180.00
900055611-0019	1.73	2 Dec 2016	2 Dec 2012	10,000	173.00

TOTAL

46,000

**900.00
(from
statement)**

APPENDIX D

Entomological Society of Manitoba Report of the ESC Regional Director

The Entomological Society of Canada meeting was held in conjunction with ESM Winnipeg in October 2017. The new Winnipeg-based management committee, Straus, assisted in running some components of the AGM, such as registration, and will become more involved in assisting meeting planning for future AGM's. In addition to the scientific programme and the annual business meeting of the Entomological Society of Canada, a strategic planning session was held on the Saturday prior to the meeting. This meeting was attended by members of the board and invited guests. As a result of the planning session, the ESC should produce a new Vision and Mission statement and strategic plan to help set priorities over the coming years.

The current President of the ESC is Patrice Bouchard. The next meeting of the ESC will be held in Vancouver in conjunction with the BC Entomological Society and the Entomological Society of America.

The board is encouraging all members of local societies to consider membership and check to see if their membership has lapsed. Methods to attract and retain new members are being considered. One new innovation is that members can opt to have automatic renewal set up on their credit cards.

Rob Currie
Regional Director

APPENDIX E

Entomological Society of Manitoba Report of the *Proceedings* Editor

Volume 72 (2016) of the *Proceedings of the Entomological Society of Manitoba* was produced exclusively in electronic format again this year. It has been sent (or will be soon) to all members of the ESM and posted on the ESM website. Printed, unbound copies will be sent to members of the society who do not have e-mail. Volume 72 was only 45 pages in length, containing abstracts from the Annual Meeting of the Entomological Society of Manitoba held at the Freshwater Institute and in the Department of Entomology on 28–29 October, 2016, and the Minutes of the 72nd Annual Business Meeting of the Entomological Society of Manitoba held on 29 October, in the Department of Entomology.

Scientific Notes as well as full Scientific Papers are welcome. The *Proceedings* is an excellent place to publish new distribution records and faunal lists for insects and related arthropods in Manitoba. I have intentions for publications from several members, which I hope will appear in the 2017 *Proceedings*. All submitted manuscripts are peer-reviewed; all published papers are available as PDF reprints on the web. Thanks very much to Rob Currie who posts the *Proceedings* so efficiently. Issues of the *Proceedings* are fully accessible using on-line search engines. There are no page charges to authors for published manuscripts, and with our electronic format, colour images can be included in manuscript. In theory, there are no practical limits on manuscript length. All issues of the *Proceedings* are freely available to entomologists around the world. I hope we don't have any future issues without submitted papers, so if you have something of relevance to entomology in Manitoba, I encourage you to consider submitting it to the *Proceedings*.

Terry Galloway
Proceedings Editor

APPENDIX F

ENTOMOLOGICAL SOCIETY OF MANITOBA Report of the Endowment Fund Board for 2015-2016

A summary of investments and projected interest income for the fiscal year is presented below (Table 1). Interest generated by the Endowment Fund provides a basis for funding Society activities. The Endowment Fund principal was \$46,000.

Richard Westwood
Kathy Cano, Chair

Endowment Fund Guaranteed Investment Certificates

Table 1: Account information as of November 10, 2017. Interest generated during the 2016-2017 fiscal year.

Certificate No.	Principal	Interest Rate (%)	Maturity Date (Purchase Date)	Annual Interest
900055611-0016	9,000.00	2.10	Dec 12, 2019 (Dec 12 2012)	189.00
900055611-0017	9,000.00	2.00	Nov 17, 2019 (Nov 17, 2014)	180.00
900055611-0018	9,000.00	2.00	Nov 19, 2020 (Nov 19, 2015)	180.00
900055611-0019	10,000.00	1.73	Dec 2, 2021 (Dec 2 , 2016)	173.00
900055611-0020	9,000.00	2.25	Nov 10, 2022 (Nov 10, 2017)	202.50
Total	\$46,000.00			924.50

APPENDIX G

Entomological Society of Manitoba Report of the Newsletter Committee

The Newsletter Committee produced three issues of Volume 43 of the ESM Newsletter in the past fiscal year. Issue 43.1 was published in January 2017, issue 43.2 in May and issue 43.3 in October. The issues were distributed via e-mail.

The budget of the ESM Newsletter committee is expected to be minimal in future fiscal years because of the use of e-mail to distribute issues.

Thank you to those members who have contributed articles to the Newsletter. We encourage all ESM Members to contribute items of interest to the membership.

Marjorie Smith
Jordan Bannerman
Co-Editors, ESM Newsletter Committee

APPENDIX H

Entomological Society of Manitoba Report of the Social Committee

This year, the ESM New Members Social was held on 1 June at the Richmond Kings Community Centre. There were 27 members of the ESM present, as well as three new student members, for a total of 30 in attendance. Pizza was delivered to the community centre and was followed by a presentation of Dr. Jason Gibb's wild bee research. Jason Gibb is the Department of Entomology's new insect systematics and taxonomy professor. He discussed relationships between taxonomy, evolution, ecology and conservation of native wild bee pollinators. Thank you to Jason for presenting and thank you to all those who attended.

This is the second year we have used Richmond Kings Community Centre as our venue for the New Members Social. The location of was suggested two years ago because of issues and concerns with restaurant-based luncheons. Murray Harding and Nicole Carnegie at the community centre were extremely helpful with booking the venue and answering questions promptly. It is likely we will continue to hold our New Members Social at this location as the staff is helpful, the location is relatively inexpensive to rent, and it is within walking distance of the University of Manitoba campus.

Discounts were given to student members who attended this year's New Members Social.

Respectfully submitted,

Gina Karam
Chair, Social Committee

APPENDIX I

Entomological Society of Manitoba Youth Encouragement and Public Education Committee

No report.

APPENDIX J

Entomological Society of Manitoba Report of the Common Names Committee

1) Change in chair

Transfer of responsibilities for the Common Names of Insects Committee was made from Terry Galloway to Jason Gibbs. The role has traditionally been held by the Curator of the J.B. Wallis/R.E. Roughley Museum of Entomology.

On 2017-03-13, Jason approached Terry to request being involved in the Committee.

On 2017-03-14, Terry brought up the subject with John Gavloski and proposed transferring responsibility to Jason if allowable under ESM rules.

On 2017-03-17, after John checked the by-laws and with agreement of John, Terry, and Jason, the role of Chair of the Common Names Committee was transferred to Jason Gibbs.

2) Common names proposed

One common name was proposed to the Entomological Society of Canada based on a recommendation by John Gavloski.

Scientific Name: *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae)

Proposed common name: spotted-wing drosophila

Background: *Drosophila suzukii* is a serious pest of small fruit crops, including, but not limited to cherries, strawberries, raspberries, and blueberries. It was introduced from Asia and has spread rapidly across North America. This species is the focus of a great deal of active research in both North American and Europe (where it is also introduced) because of its severe economic impact. The distinctive wing spots of the male are the basis of the common name, which is often abbreviated to 'SWD'.

Spotted-wing drosophila is also the official common name used by the Entomological Society of America.

Current status: Pending.

APPENDIX K

Entomological Society of Manitoba

Report of the ESM Student Awards and ESM Scholarship Committee

I would like to acknowledge the contributions of Richard Westwood, who chaired this committee for about 20 years, and stepped down in order to accept another position within our Society. Richard was an organized and fair-minded Chair, and did a great job to serve our students and our Society. Thanks Richard!

Student Achievement Award: Awarded to a student who is in a Bachelor's degree programme or recently completed a programme. This award recognizes students who have shown exceptional interest in entomology as evidenced by their insect collections, insect photography, published articles of entomological interest, insect experiments and/or outstanding contributions during summer employment.

This year's winner of the Entomological Society of Manitoba Student Achievement award is Mr. Ivan Drahun, who is in his final year as an undergraduate Biochemistry student at the University of Winnipeg (U of W). Ivan has taken all of the Entomology-related courses available through the Department of Biology at the U of W, and has written a directed studies project on the potential vector competence of North American mosquito species (including some in Manitoba) for exotic viruses such as Zika and Chikungunya. Ivan is currently working on an honours project evaluating the oviposition decisions of two species of mosquitoes with respect to organic content in aqueous habitats.

Orkin Student Award: This award is designed to foster and encourage student interest in general Entomology including natural methods of insect pest control and the proper use of insecticides. Candidates must have a demonstrated interest in entomology, superior scholastic ability, high research potential, originality and industriousness in their university courses and/or summer work.

This year's winner of the Orkin award is Mr. Corey Blad. Corey is close to completing a B.Sc with a major in Plant Biotechnology and a minor in Entomology at the University of Manitoba. Corey has worked in the Department of Entomology as a student lab technician since 2015, helping with a variety of projects such as maintaining insect colonies, setting insect traps, and identifying insects. Corey is currently working under the supervision of Dr. Alejandro Costamagna on a project that he helped to develop, to determine if *Brassica napus* (canola) produces more seeds when infested by the butterfly, *Pieris rapae*, as a means of reproductive escape from predation.

The ESM Graduate Scholarship: This scholarship is awarded to students in a M.Sc. or

Ph.D. programme related to entomology at the University of Manitoba, University of Winnipeg or University of Brandon. Students must be enrolled in their graduate programme for at least 12 months prior to 1 Oct of the award year. This award recognizes superior scholastic ability, high research potential as evidenced by industriousness, good judgment, originality, a conscientious attitude and organizational ability, and excellent communication skills.

The 2017 Scholarship winner is Ms. Martine Balcaen. Martine is enrolled as an M.Sc. candidate in the Department of Biology in the Bioscience and Technology Programme at the University of Winnipeg and is supervised by Dr. Richard Westwood. Martine received her B.Sc. (Honours) in Environmental Science from the University of Calgary in 2016. Martine's M. Sc. research focuses on better understanding the dispersal behaviour of adult mosquitoes in relation to climatic and habitat variables. The ultimate goal is to improve mosquito management and the efficiency of control measures, by integrating the enhanced understanding of the dispersal behavior into Geographic Information Systems (GIS) models for mosquito distribution.

Committee: Taz Stuart and Jeffrey Marcus.
Désirée Vanderwel, Chair, October 21, 2017.

APPENDIX L

Entomological Society of Manitoba Fundraising Committee

The Fundraising Committee raised a total of \$1,350.00 from 11 donors to cover some of the costs of the AGM, such as bringing in the speakers from out of town. Orkin PCO Services provided an additional \$200 for the Orkin Student Award.

The Fundraising Committee acknowledges the continued support of our sponsors in making the AGM successful in providing quality speakers for this very educational event.

The Fundraising Committee would appreciate leads from its members for parties who are using the valuable services entomologists provide, so the Committee could solicit them for financial support.

Joel Gosselin, Chair,
Fundraising Committee

APPENDIX M

Entomological Society of Manitoba Report of the Scientific Programme Committee

ESC-ESM JAM 2017 was held 22-25 October 2017 at the Fairmont Hotel in Winnipeg, MB. There was diverse lineup of invited speakers from across Canada and the USA. There were five keynote presentations, seven symposia as well as 64 student presentations and 78 regular submitted papers. There were over 224 people registered for the meeting. The program and abstracts are available online.

Although we do not have the final amounts, we expect to show a small profit for the meeting, that may be as high as a few thousand dollars, which under the new guidelines will be split equally with the ESC.

I would like to thank the many volunteers that made this event a success, some are listed below.

2017 JAM Local Organizing Committee

Meeting Chair:	Rhéal Lafrenière
Scientific Program Chair:	Paul Fields
Scientific Program Committee:	Megan Cowell, Ale Costamagna, Rhéal Lafrenière Bob Lamb
Registration:	Ian Wise
Treasurer:	Ian Wise
Webmaster:	Jordan Bannerman
Fundraising:	Brent Elliott
Audio Visual:	Rob Currie
Awards:	Katherine Rochon
Graduate Student Symposium:	Miles Zhang and Anne-Sophie Caron
Photography:	Jason Gibbs, Tyler Wist
Logo Design:	Aldo Ríos
Translation:	Véronique Martel and Lorraine Forbes

Paul Fields
Scientific Chair ESC-ESM JAM 2017

APPENDIX N

Entomological Society of Manitoba Report of the ESM Membership Committee

There was a change to the Membership Chair in 2016-2017: The duties of the Chair were transferred to the Secretary. The change allows the ESM to have one person receiving memberships and maintaining our data base, rather than having our membership list shared between the Treasurer, Membership Committee, and Secretary.

Thank you to Désirée Vanderwel for her dedicated years as Membership Chair. We currently have 86 members. Unfortunately, due to a software issue, the number of members in 2016 was lost. There were 101 members in 2015.

The reduction in membership was due to the removal of inactive members from our data base. While updating our list, I found that 43 members were either inactive, required renewals, or needed updates to contact information.

Please continue to encourage students and colleagues to join the ESM.

Sarah Semmler
ESM Secretary

APPENDIX O

Entomological Society of Manitoba Web Site Report

The Entomological Society of Manitoba operates a website that is currently hosted through the public access portion of Paul Field's personal University of Manitoba web page. The website contains information about the Society and its committees, dates of meetings, programs for meetings, and provides links to other sources of entomological resources on the web.

The ESM site is currently kept up to date with regular updates of newsletters, proceedings, reprints of papers from the proceedings and announcements for the annual general meeting. Copies of all issues of the Proceedings of the Entomological Society of Manitoba and the former journal the "Manitoba Entomologist", and the historical publication of the ESC, "Entomologists of Manitoba" can now be found on the site.

Any suggestions for additions or changes to the website should be forwarded to Rob Currie, Dept. of Entomology, University of Manitoba (rob_currie@UManitoba.ca).

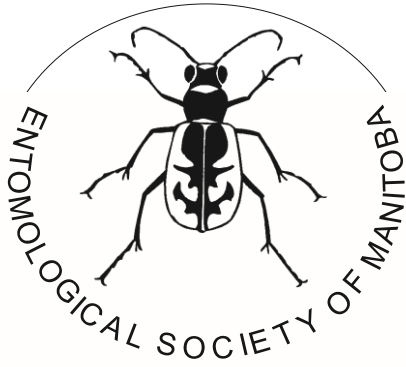
Rob Currie, ESM Webmaster

APPENDIX P

Entomological Society of Manitoba Election Report

Elections closed October 29, 2017 for the Entomological Society of Manitoba offices of President-Elect, Member-at-Large, ESC Regional Director and Approval of Changes to ESM Bylaws. The successful candidate for President-Elect is Erica Smith, for Member-at-Large is Jason Gibbs and for ESC Regional Director is Kateryn Rochon. Changes to the ESM Bylaws were approved. We thank all candidates for their willingness to participate in the election. Formal announcement and commencement of terms will be at and after the ESM Annual Business Meeting, respectively.

Sincerely,
Colin Demianyk, Chairperson, Scrutineer Committee
Noel White, Witness



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